AN ASSESSMENT OF FLOOD DAMAGE POTENTIAL ALONG THE MAGAGUADAVIC RIVER VALLEY FROM SECOND FALLS TO ST. GEORGE

PREPARED FOR:
CANADA - NEW BRUNSWICK FLOOD DAMAGE REDUCTION PROGRAM

PREPARED BY:
WMS ASSOCIATES LTD

APRIL 1989

90-06374/

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WMS 2904

April 1989

Executive Summary

1. INTRODUCTION

A principal objective of this study was to determine the maximum level of flooding in the Study Area. This was based on a review of historic and archival information, and interviews with local residents and officials. An analysis was also made of the development potential and population trends within the Study Area so that the impact of flooding on future development could be determined.

The Study Area is comprised of the Magaguadavic River Valley from Second Falls to St. George. This area also includes the community of Canal, part of Lake Utopia and the area subject to flooding adjacent to the River.

2. FLOOD DOCUMENTATION

An initial investigation to determine the level of historic flooding was based on previous reports, photographs, newspaper and magazine articles and other available data sources. This review identified the dates and brief descriptions of thirteen (13) major flood events. The physical effects of the floods, such as the maximum extent of flooding and the maximum water level were identified through field investigations.

Personal interviews were conducted with local residents and officials. All those interviewed had first hand knowledge of past flooding. A questionnaire was developed to guide the interviewer, ensuring that interviews were conducted consistently. The objective was to identify known flood limits from past events and to obtain available photographic evidence of these.

Not all the water levels could be estimated with the same accuracy, therefore, a ranking method was developed to compare the reliability of points obtained. The objective was to ensure that the points which were later surveyed provided adequate coverage of the Study Area and a sampling from each known flood.

3. DATA COMPILATION

The data collected were used to produce a list of events with enough detail to provide a point in the field at which the water level could be obtained. A total of 56 of these "reference points" were found in the Study Area. At most of the reference points, information was obtained on more than one flood, so that a total of 103 possible flood water levels were found.

A preliminary analysis was made of these water level reference points. The resulting information was used as a guide to the field survey crew. In addition, a supplementary report was produced which summarized the findings of the interviews and archival research. The report showed the locations of the known flood levels and included a description of the reference points, pictures of the original building affected or flood lines and pictures of the present structures.

During the field survey, elevations for 40 reference points were determined. The horizontal coordinates of 15 of these points were established and the others were located by general map reference. All temporary benchmarks were identified and described for possible later use.

4. HYDROTECHNICAL STUDIES

Hydrotechnical studies were carried out in order to make a comparison between the water levels of past flood events and the 1 in 100 year open water flood level. This comparison was made at two locations in the Magaguadavic River valley:

- between Second Falls and Bonny River; and
- at the dam at St. George.

The flows for the 1 in 100 year event were estimated at each of these locations using regional flood frequency methods. The results were compared to single station frequency analysis using the Magaguadavic River hydrometric gauge at Elmcroft (Station 01AQ002) located 7 km upstream of Second Falls. The 1 in 100 year instantaneous peak flows were estimated to be:

At Bonny River, 1 in 100 year flow: **795 m^3/s**

At St. George, 1 in 100 year flow: **946 m^3/s**

The water levels at the dam at St. George which would result from a 1 in 100 year open water flood are estimated using a discharge curve developed for the dam and storage above the dam. The estimated maximum water level from the 1 in 100 year open water flood is 20.7 m at the dam.

The hydraulic calculations in the upstream portion of the Study Area are based on cross-sectional information collected as part of the field program. The HEC-2 backwater model was used to model the flow profile. The flow profile indicated by water levels found during the study was used to approximate the slope

of the water surface in the area upstream of the dam and was used for comparison to the model results.

5. ENVELOPE OF MAXIMUM FLOODING

A water surface profile of the River was developed by plotting of the points collected in the field. This allowed a verification of the consistency and reliability of the points for each flood. A profile connecting the known points for each flood was drawn and from this, the envelope of maximum historic flooding was determined. The analysis of the data showed that the 1923 open water flood event represented the maximum flooding event. There have been two major changes on the River since 1923, both of which would influence the flood levels on the River: the dam at St. George has been raised by 1.5 m in 1950 and the bridge above the dam was replaced in 1974. However, without a detailed hydraulic analysis, it is difficult to determine the impact of the changes. It has been assumed that the influences would offset one another and the water levels would not be drastically different from the levels which could occur with a flow similar to the estimated magnitude of the 1923 event.

The results were also compared to the 1 in 100 year open water flood levels. It was found that the 1923 levels were approximately 0.6 m higher over the entire Study Area.

6. DEVELOPMENT POTENTIAL

The analysis of population and development trends used the envelope of the maximum flood to determine the area affected and to evaluate the impact of flooding.

Land use and demographic information were used in determining the past development trends and future development potential along

the Magaguadavic River. From existing mapping and aerial photographs it was estimated that there is a total of 58 households, and a total current population of 157, within the area affected by floods on the River. No significant amount of residential development or population growth is expected within the floodplain. Almost half of the employment in the Town of St. George and St. George Parish is in stable employment sectors such as retail and service sectors, therefore little variance from the projected population or development within the Study Area should be expected.

7. CONCLUSIONS AND RECOMMENDATIONS

This study has found that the open water flood of 1923 is the highest on record, exceeding the levels reached by any other flood, whether caused by open water or ice jamming. It has been found that a minor amount of flooding occurs every year in the Study Area and that major floods are relatively frequent. The information collected on flooding has been used to establish the maximum envelope of flooding for the Study Area.

A detailed hydrotechnical study of the area would permit the flood elevations to be more firmly established. Such a study would permit an assessment of the impact of changes which have been made to the River valley since the flood of record in 1923, such as those to the bridge and dam at St. George. A hydrotechnical study is not warranted, however, due to the small number of houses affected and the limited development potential of the area.

There are not enough points, nor sufficient cross-sectional information to provide the exact extent of flooding along the River. Water levels are generally reported as heights against structures and not as the maximum extent of inundation.

Therefore the water levels selected to define the maximum limit of flooding are based on the maximum elevation of flood waters in each section of the River.

To permit a full determination of the extent of flooding, cross-sections could be taken to supplement the available mapping of the area. The use of existing temporary benchmarks which were established for this study would reduce the difficulty and cost of obtaining the cross-sections.

Demographic analysis shows that within the next five to ten years there will be very little development within the floodplain area. Most of the development within the Town limits will probably be in the urban area of the Town away from the floodplain. Any other development will continue to be along the transportation routes, as is presently the case.

This study can provide a useful guide to any development which does take place within the Study Area. The elevations of maximum flooding determined by this study can be used to ensure that new development does not take place in areas which could be affected by flooding. The profile of maximum flooding should be used as a guide to determine the elevation of flooding in the area of interest.

Résumé administratif*

1. INTRODUCTION

Un des principaux objectifs de cette étude était de déterminer le niveau de crue maximum dans la région étudiée. Cette étude était fondée sur un examen des données archiviques et historiques, ainsi qu'à partir d'entrevues avec les résidents et les représentants locaux. Les tendances démographiques et les possibilités de développement au sein de la région étudiée ont également été analysées afin de déterminer les effets des inondations sur le développement à l'avenir.

La région étudiée comprend la vallée de la rivière Magaguadavic, à partir de Second Falls jusqu'à St. George. Elle englobe aussi la localité de Canal, une partie du lac Utopia et la plaine inondable près de la rivière.

2. DOCUMENTATION SUR LES INONDATIONS

Une enquête initiale visant à déterminer le niveau de crue historique a été effectuée à partir des rapports précédents, des photographies, des articles de journaux, des revues et d'autres sources de données disponibles. Cette étude a permis d'identifier les dates et de fournir une courte description de treize (13) inondations majeures. Les effets matériels des inondations, tels que le niveau de crue maximum et le niveau d'eau maximum ont été établis à la suite d'études sur place.

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* Translated by McLaughlin Translation Company Ltd.

Des entrevues ont été effectuées avec des résidents locaux et desreprésentants. Toutes les personnes interviewées avaient été personnellement témoins des inondations par le passé. Un questionnaire a été préparé pour orienter l'intervieweur, afin que les entrevues soient effectuées de façon constante. L'objectif était d'identifier les limites des inondations connues à partir des événements précédents et d'obtenir les preuves photographiques disponibles de ces inondations.

Les niveaux d'eau n'ont pas tous été calculés avec la même exactitude; une méthode de classement a donc été élaborée pour comparer la fiabilité des points obtenus. On voulait s'assurer que les points étudiés ultérieurement couvrent adéquatement la zone étudiée et constituent un échantillonnage de chaque inondation connue.

3. COMPILATION DES DONNÉES

Les données recueillies ont servi à préparer une liste des événements assez détaillée pour fournir un point de référence sur place afin de déterminer le niveau d'eau. Au total, 56 de ces "points de référence" ont été repérés dans la zone étudiée. A la plupart de ces points de référence, on a obtenu de l'information sur plus d'une inondation, un total de 103 niveaux de crue possibles ayant été repérés.

Une analyse préliminaire de ces points de référence du niveau d'eau a été effectuée. Les données de cette analyse ont servi de guide pour l'équipe ayant effectué l'étude sur place. De plus, un rapport supplémentaire résumant les résultats des entrevues et de la recherche archivique a été rédigé. Ce rapport indiquait les emplacements des niveaux de crue connus et comprenait une description des points de référence, des photos des premiers

bâtiments affectés ou des lignes des crues et des photos des structures actuelles.

Au cours de l'étude sur place, on a établi les niveaux d'élévation pour 40 points de référence. Les coordonnées horizontales de 15 de ces points ont été établies, les autres ayant été localisées à partir d'une carte générale. Tous les points de repère temporaires ont été identifiés et décrits pour fins d'utilisation ultérieure.

4. ÉTUDES HYDROTECHNIQUES

Des études hydrotechniques ont été effectuées afin d'établir une comparaison entre les niveaux d'eau des inondations précédentes et le niveau de crue sans glace pour une période de récurrence d'une fois tous les cent ans. Cette comparaison a été établie à deux endroits dans la vallée de la rivière Magaguadavic :

- entre Second Falls et rivière Bonny; et
- au barrage de St. George.

Les débits pour une récurrence d'une fois tous les 100 ans ont été déterminés à chacun des endroits à l'aide de méthodes régionales de fréquence de crue. Les résultats ont été comparés aux analyses de fréquence d'une seule station utilisant l'indicateur du niveau hydrométrique de la rivière Magaguadavic à Elmcroft (station 01AQ002) située à 7 km en amont de Second Falls. Les débits de pointe instantanés d'une récurrence d'une fois tous les 100 ans ont été estimés comme suit :

- Bonny River, débit d'une fois tous les 100 ans : 795 m^3/s
- St. George, débit d'une fois tous les 100 ans : 946 m^3/s

Les niveaux d'eau au barrage de St. George provoqués par une inondation sans glace en 100 ans sont estimés à l'aide d'une courbe des débits jaugés établie pour le barrage et l'emmagasinage au-dessus du barrage. Le niveau d'eau maximum d'une inondation tous les 100 ans est estimé à 20,7 m au barrage.

Les calculs hydrauliques dans la partie en amont de la zone étudiée sont fondés sur les données d'échantillons représentatifs recueillies dans le cadre du programme sur place. Le modèle du remous HEC-2 a été utilisé pour établir le profil du débit. Le profil du débit indiqué par les niveaux d'eau constatés pendant l'étude a servi à établir approximativement la pente de la ligne d'eau de surface dans la zone en amont du barrage et a été utilisé pour fins de comparaison avec les résultats du modèle.

5. ENVELOPPE DES CRUES MAXIMALES

Un profil de l'eau de surface de la rivière a été établi en traçant les points recueillis sur place. Cette démarche a permis de vérifier la constance et la fiabilité des points pour chaque inondation. On a dressé un profil reliant les points connus pour chaque inondation à partir duquel l'enveloppe la crue maximale historiques a été déterminée. L'analyse des données a révélé que l'inondation sans glace de 1923 représentait les crues maximales. Depuis 1923, il est survenu deux changements majeurs dans la rivière qui influenceraient les niveaux de crue de la rivière : le barrage de St. George a été surélevé de 1,5 m en 1950 et le pont en amont du barrage a été remplacé en 1974. Sans une analyse hydraulique détaillée, il est difficile toutefois de déterminer l'impact de ces changements. On a présumé que les effets se compenseraient mutuellement et que les niveaux d'eau ne varieraient pas de façon dramatique par rapport aux niveaux qui

se produiraient avec un débit semblable à celui calculé pour l'inondation de 1923.

Les résultats ont été comparés aux niveaux de crue d'une période de récurrence d'une fois tous les 100 ans. On a constaté que les niveaux de 1923 étaient d'environ 0,6 m supérieurs à ceux de l'ensemble de la zone étudiée.

6. POSSIBILITÉS D'AMÉNAGEMENT

L'analyse des tendances démographiques et d'aménagement a été fondée sur l'enveloppe des crues maximales pour déterminer la zone affectée et évaluer l'impact des inondations.

Les données démographiques et d'utilisation des terres ont servi à déterminer les tendances précédentes en matière d'aménagement et les futures possibilités d'aménagement le long de la rivière Magaguadavic. A partir des cartes et des photographies aériennes actuelles, on estime à 58 le nombre total de ménages, et à 157 la population actuelle totale, dans la zone affectée par les crues de la rivière. On ne prévoit aucun aménagement résidentiel ou croissance démographique considérable dans la plaine inondable. Près de la moitié des emplois dans la ville et dans la paroisse de St. George se trouvent dans des secteurs d'emploi stables, tels que la vente au détail et les services, ce qui laisse prévoir un écart très minime par rapport aux prévisions démographiques ou d'aménagement dans la zone étudiée.

7. CONCLUSIONS ET RECOMMANDATIONS

Cette étude a révélé que l'inondation sans glace de 1923 avait atteint des niveaux records, ayant dépassé les niveaux atteints par toute autre inondation, causée par la crue des eaux sans glace ou par les embâcles de glace. On a constaté qu'un nombre

minime d'inondations se produisent chaque année dans la zone étudiée et que les crues majeures sont relativement fréquentes. Les données recueillies sur les inondations ont servi à établir l'enveloppe maximale des inondations pour la région étudiée.

Une étude hydrotechnique détaillée de la zone permettrait d'établir de façon plus précise les niveaux de crue. Une telle étude permettrait d'évaluer l'impact des changements qui ont été apportés dans la vallée de la rivière depuis l'inondation de 1923, tels que le pont et le barrage à St. George. Une étude hydrotechnique n'est pas justifiée toutefois en raison du petit nombre de maisons touchées et des possibilités d'aménagement limitées de la région.

Il n'existe pas suffisamment de points ou d'information de référence pour prévoir l'étendue exacte des inondations le long de la rivière. Les niveaux d'eau sont généralement signalés en fonction des hauteurs contre les ouvrages et non pas en fonction de l'étendue de l'inondation maximale. Les niveaux d'eau choisis pour définir la limite maximale des inondations sont fondés sur l'élévation maximale des crues dans chaque section de la rivière.

Pour déterminer de façon détaillée l'étendue des inondations, on pourrait utiliser des analyses de coupes transversales à titre de complément des cartes disponibles de la région. L'utilisation des points de repère temporaires actuels qui ont été établis aux fins de cette étude réduirait les difficultés et le coût de l'obtention des analyses de coupes transversales.

L'analyse démographique démontre que très peu d'aménagement sera effectué à l'intérieur de la plaine inondable au cours des cinq à dix prochaines années. La majeure partie de l'aménagement à l'intérieur des limites de la ville se fera probablement dans la zone urbaine, loin de la plaine inondable. Tout autre

aménagement continuera de se faire le long des routes de transport, comme c'est actuellement le cas.

Cette étude peut servir de guide valable pour tout aménagement dans la zone étudiée. Les élévations des crues maximales déterminées par cette étude peuvent servir à éviter tout nouvel aménagement dans les zones susceptibles d'être inondées. Le profil des inondations maximales devrait servir de guide pour déterminer l'élévation des crues dans la région qui nous intéresse.

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1.0 INTRODUCTION

1.1 Objectives

A principal objective of this study was to determine the maximum extent of flooding in the Study Area. This was based on a review of historic and archival information, and interviews with local residents and officials. An analysis was also made of the development potential and population trends within the Study Area so that the impact of flooding on future development could be determined.

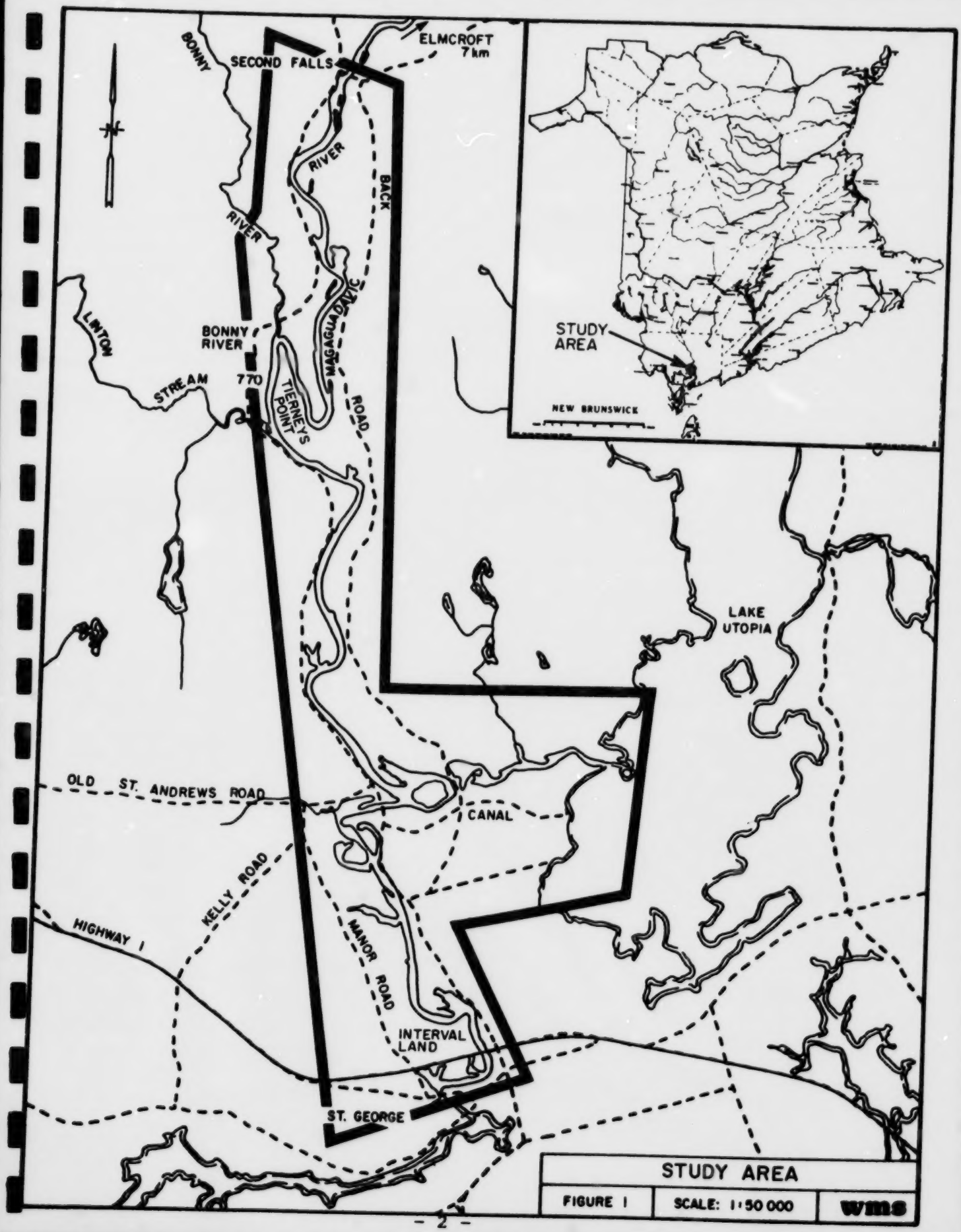
1.2 Study Area

The Study Area is comprised of the Magaguadavic River Valley from Second Falls to St. George (Figure 1). This area also includes the community of Canal, part of Lake Utopia and the area subject to flooding adjacent to the River.

1.3 Scope of Work

An initial investigation to determine the level of historic flooding used previous reports, photographs, newspaper and magazine articles and other available data sources. These provided the dates and brief descriptions of major flood events. The physical effects were identified through field investigations.

Personal interviews were conducted with local residents and officials who have first hand knowledge of past floods. A questionnaire was developed to guide the interviewer, ensuring that interviews were conducted consistently. The objective of the interviews was to identify known flood limits from past events and to obtain available photographic evidence of these.


BONNY
SECOND FALLS
ELMCROFT
7 km
RIVER
BACK
RIVER
MAGAGUADAVIC
LINTON
BONNY
RIVER
STREAM
770
TIERNEYS
POINT
ROAD
STUDY
AREA
NEW BRUNSWICK
LAKE
UTOPIA
OLD ST. ANDREWS ROAD
CANAL
KELLY ROAD
HIGHWAY 1
MANOR ROAD
INTERVAL
LAND
ST. GEORGE
STUDY AREA
FIGURE 1
SCALE: 1:50 000
WMS

A ranking system was developed to evaluate the reliability of the flood levels identified. The objective was to ensure that the points which were later surveyed provided adequate coverage of the Study Area and a sampling from each known flood.

A water surface profile of the River was developed by plotting of the points collected in the field. This allowed a verification of the consistency and reliability of the points for each flood. A profile connecting the known points for each flood was drawn and from this, the envelope of maximum historic flooding was determined.

The open water flows for a 1 in 100 year return period were estimated using regional flood frequency methods. Limited cross-sectional information which was collected during the field program allowed for an estimation of the relationship between flow and water level. An estimate of the 1 in 100 year open water flood level was made for the Magaguadavic River near Bonny River area and for the St. George area near the dam and these were compared with the maximum historic flood limits.

The analysis of population and development trends used the envelope of maximum flooding to determine the area affected and to evaluate the impact of flooding.

1.4 Authorization

WMS Associates Limited has undertaken this study for the New Brunswick Department of Municipal Affairs and Environment, under the Canada - New Brunswick Flood Damage Reduction Program. The study has been completed in consultation with a Technical Committee comprised of representatives from the Inland Waters Directorate of Environment Canada and from the Water Resource

Planning Branch of the New Brunswick Department of Municipal Affairs & Environment.

2.0 BACKGROUND INFORMATION

This Chapter discusses some of the flood which have occurred in the Study Area in the past, and describes the nature of flooding along the River. The major data sources which were used in this study are described, their location and type of information they provided is discussed.

2.1 Past Flooding

The Magaguadavic River has a long history of flooding, with some flooding in the River valley occurring every year. There are historical records of floods which occurred in the 1800's. Historic floods of note occurred in 1936, 1950, 1961 and 1970. The washing away of bridges, and the loss of homes and livestock are among the damages which occurred as a result of these floods. The flooding is most commonly due to extreme open water flows, such as occurred in 1923, but ice jam flooding, such as in 1970, has also occurred. The most notable flood occurred in 1923 when there was extensive flooding along the River. Farms, homes and cottages were inundated and the mill located at St. George was damaged. Estimated flood damages exceeded $3 million (1983 $) (Kindervater, 1985).

In late March 1979, a major flood event caused by high open water flows occurred requiring the evacuation of 25 families at Bonny River. Sections of Route 770 from Second Falls to St. George and of Manor Road between Route 1 and Brunswick Drive were inundated. This flood did not lead to the highest water levels on record, but it is the best documented event. Shortly after the event, the New Brunswick Department of the Environment under the direction of the Canada-New Brunswick Flood Damage Reduction Program, commissioned a study to locate as many high water points as possible (Proctor and Redfern, 1979).

2.2 Data Sources

Available information on flooding along the Magaguadavic River was collected and reviewed, including a compilation of reports on historic flood events. A major source of information on the historic floods was from the Inland Waters Directorate (IWD) (Kindervater, 1985). This report provided a summary of the known flooding events in New Brunswick as recorded in newspapers and other sources, and served as a starting point for this study in the search for additional archival information.

Historic streamflow data was obtained for the Magaguadavic River at the Elmcroft hydrometric gauge (Station 01AQ002) from IWD for the period of record (1917-1933, 1943-present).

In the course of the collection of background data, the available sources of relevant data from provincial and federal governments were reviewed, including both their library and Departmental files. In obtaining these data, individuals with knowledge of the sources were interviewed. This provided a more focused effort than could be possible solely from a review of published literature. These sources included the following:

- Inland Waters Directorate, Environment Canada;
- Saint John River Forecast Centre;
- Water Resource Planning Branch of the New Brunswick Department of Municipal Affairs and Environment;
- New Brunswick Electric Power Commission; and
- Emergency Measures Organization.

In addition, libraries, historical societies, professional photographers, local experts and newspapers were approached for additional information which might be useful for this study. The Provincial Archives and the Harriet Irving Library of the University of New Brunswick were consulted for microfilms of the following newspapers, and to obtain information and photographs on past flooding events:

- Saint John Telegraph-Journal:
  April 1923 to Sept 1988 - specific events

- Fredericton Daily Gleaner:
  April 1923 to Sept 1988 - specific events

- Saint Croix Courier:
  July 1958 to June 1982 - all papers
  Jan 1887 to July 1958 - specific events

3.0 FLOOD DOCUMENTATION

3.1 Introduction

The flood documentation and development potential components of the study were carried out independently. The former is presented in this Chapter, the development potential component is described in detail in Chapter 6 of this report.

This Chapter presents the methodology used in the collection and compilation of data for the flood documentation. This Chapter also presents the methodology used to compile and evaluate the information so that water levels could be located in the field. Some of the major flood events on the River are described and the information obtained for each is discussed. Finally, the field survey is described; this presents the methodology which was used to determine the location and elevations of reference points used in this study.

The flood documentation section of the study began with the collection and thorough review of all existing information on past floods. This is summarized in Section 3.2 and includes archival sources, interviews and questionnaires.

Mapping for the area was collected and assembled. Maps of the Study Area were available at the 1:50,000 and 1:10,000 scales, and at a scale of 1:2,400 for the communities of St. George and Canal. The maps of the area were used to maintain a record of the location of points of flooding as they were identified. Information such as ice jam locations, water levels, and photograph locations were pin-pointed on the map, giving a visual presentation of the data to aid in its correlation. This process began with the known information on water levels from the report

prepared following the 1979 flood event (Proctor and Redfern, 1979).

The streamflow data on the Magaguadavic River at Elmcroft was used for the analysis of the open water flows to determine the 1 in 100 year return period flood profiles. It was also used in the presentation of the antecedent conditions of each identified flooding event, which assisted with the confirmation of the time and dates of the events.

3.2 Data Collection

3.2.1 Archival Sources

The Town of St. George does not have its own newspaper which would give direct reports of flooding events in the local area. Flooding on the River usually occurs at the same time as flooding in other nearby basins and is not usually a major item in the newspaper accounts of regional flooding. The more spectacular floods, such as 1923 and 1970, did get extensive coverage, but the minor floods received only passing mention. The archives of the Saint Croix Courier, Saint John Telegraph-Journal and the Fredericton Daily Gleaner were carefully examined to determine the details of the known flood events.

Other data sources, such as the Provincial Archives and the records of the New Brunswick Department of Municipal Affairs and Environment, were also examined. These provided some additional background information on the floods but generally did not provide details which could lead to the determination of water levels in the field.

The Inland Waters Directorate maintains a hydrometric gauge on the Magaguadavic River at Elmcroft, approximately 7 km upstream

of Second Falls. The gauge was first installed in 1917 by the Canadian Department of the Interior, Dominion Water Power Branch and provides a long record of flow on the River. The record of the 1923 flood (Smith, 1923) provided a commentary on flooding and the observer notes from the Elmcroft gauge provided a limited amount of additional information on the event.

Dates of ice out, i.e., the date when ice breaks up, on Lake Utopia were provided by two local sources (C. Tatton, pers. comm. and K. Chase, pers. comm.); both these gave a continuous record dating back to 1895. A copy of the ice out dates for each year is included in Appendix A.

3.2.2 Interviews and Questionnaires

It became apparent early in the study that the best source of information on flooding would be from residents of the area. Therefore a program of interviews was conducted over the period of September 26 to October 12, 1988. Interviews were conducted with 50 residents and local officials in St. George, Bonny River, Second Falls, Blacks Harbour, Pennfield, St. Stephen and Canal. A list of the persons interviewed in included in Appendix B of this report.

Initial contact was made with town officials and operators of the dam at St. George. These people were able to provide preliminary descriptions of the nature and extent of flooding as well as providing an initial list of people to be contacted for further information. In addition, the report by Proctor and Redfern (1979) provided a relatively recent list of people affected by flooding and locations at which flood levels were recorded.

In order to guide the interviewer, separate questionnaire forms were developed for:

- interviews with officials;
- interviews with residents; and
- a flood event information form.

Samples of these forms are provided in Appendix B.

The form which was used to guide discussions with officials was intended to provide leads to other residents who may have specific information on the flooding in the area. The residents were asked general questions on flooding, including dates and locations of specific flood events. For each flood event, an additional questionnaire was filled out in order to obtain information specific to the flood, including:

- date of flood event;
- type of flood (ice run, ice jam, open water);
- location of ice runs or ice jams;
- extent, location and height of flood waters;
- direct or indirect damages (type of damage and cost);
- location of any physical evidence of flooding (eg. high water marks, ice scars); and
- availability of photographs of the event.

The use of a separate questionnaire for each flood facilitated cross-referencing of interviews for the same flood events. The forms were also very useful in maintaining consistency in the method in which the interviews were carried out and to ensure that flood details, photographs of each event and leads to additional residents who might have additional knowledge were obtained.

3.3 Data Compilation

Historical records indicated that there has been frequent flooding on the Magaguadavic River. Residents report that there is some degree of flooding every year, especially in the area called "the interval lands" located north of the highway bridge on Highway 1 (Figure 1). This low and marshy area is typically flooded at least once a year. There are other areas along the River which are subject to some degree of flooding every year; these include the Canal area, and the low lying areas along the River between Second Falls and Bonny River. The residents of the River valley do not consider the yearly flooding to be serious and do not perceive a flood to occur until it begins to encroach on roads or inundate houses.

Table 1 summarizes the known flood events on the River and indicates the events for which data was obtainable during this study.

TABLE 1

SUMMARY OF FLOODS ON THE MAGAGUADAVIC RIVER

Flood Dates		Peak Flow[1]		Ice Out	Ice Out		
Year	Date	(m^3/s)	Date	Utopia[2]	Elmcroft[3]	Type	No of Points
1887	Apr 25-May 14	--	--	--	--	?	0
1900	Oct 8-12	--				?	0
1901	Apr 7-12					?	0
1902	Mar 17-23			Mar 25		Ice Run	2
1920	Apr 6-20	323	Apr 16	Apr 16	Apr 5	Open Water	
1923	Apr 28-May 3	1700E	May 1	Apr 10	Apr 17	Open Water	14
1934	Apr 16-24	--		Apr 26	--	Open Water	0
1936	Mar 16-25	--		Apr 14	--	Ice Jam	2
1940	Apr 15-20			Apr 20		Ice Run	0
1950	Apr 20-24	377	Apr 23	Apr 21	Apr 10	Open Water	4
1953	Mar 26-Apr 3	268	Mar 27	Mar 27	Mar 24	Open Water	2
1954	Apr 16-24	436	Apr 18	Apr 17	Apr 13	Open Water	4
1959	Dec 3-Dec 4	126	Dec 4	--	Dec 3	Open Water	2
1961	May 25-31	657	May 28	May 30	Apr 19	Open Water	6
1963	May 1-10	334	May 3	May 2	Mar 26	Open Water	2
1967	Mid May	221	May 13	Apr 17	Mar 31	Open Water	0
1970	Feb 2-6	722	Feb 4	May 4	Mar 29	Ice Jam	6

(Continued)

TABLE 1 (Cont'd)

SUMMARY OF FLOODS ON THE MAGAGUADAVIC RIVER

Flood Dates		Peak Flow[1]		Ice Out	Ice Out		No of
Year	Date	(m^3/s)	Date	Utopia[2]	Elmcroft[3]	Type	Points
1972	May 5-11	185	May 5	Apr 18	Apr 9	Open Water	0
1973	Apr 30	337	Apr 30	Apr 12	Mar 16	Open Water	1
1976	Feb 2	119	Feb 3	Apr 16	Mar 28	Ice Run	0
1979	Mar 26-Apr 5	390	Mar 26	Apr 13	Mar 25	Open Water[4]	23
1985	Spring			Apr 19	Apr 1	Ice Jam	0
1986	Jan 29	190	Jan 28	Apr 15	Mar 31	Ice Jam	1

Notes:
1 Maximum Daily Discharge at Elmcroft (Station 01AQ002)
2 Lake Utopia records from K. Chase and C. Tatton (pers. comm.)
3 Last date of ice present as indicated in hydrometric record for Elmcroft
4 Ice jam at Second Falls
E Estimated

3.3.1 Preliminary Evaluation of Data Points

The data collected during the interview survey with local residents and officials was assembled and reviewed. This information was supplemented by information from the archival sources where appropriate. The data were used to produce a list of events with enough detail to provide a point in the field at which the water level could be obtained. A total of 56 of these "reference points" were found in the Study Area. At most of the reference points, information was obtained on more than one flood, so that a total of 103 possible flood water levels were found.

Not all the water levels could be estimated with the same accuracy, therefore, a ranking method was developed to compare the reliability of points obtained. The subjectivity of the system made it difficult to assign a ranking which could be measured as a variation in elevation of the points. Table 2 presents the categories used in the ranking system and the assumed range of elevation. This range is recognized as being a subjective interpretation of the ranked categories.

Table 2
Ranking of Reference Points

Label	Description	Range
G	Good	± 25 mm
R	Reasonable	± 75 mm
A	Approximate	± 150 mm
V	Vague	± 300 mm
Y	No Point	

"Good" points are the most reliable, these are points for which a photograph exists of the peak water level, or for which there was physical evidence from which a level could be obtained.

"Reasonable" points are those for which there is a photograph, but the building has been changed since the photograph was taken. Reasonable points are also those for which a measurement was made by the resident or by others at the time of flooding but the exact reference was not recorded as a physical mark or by photography.

"Approximate" points are typically levels related to existing structures against which the resident was able to demonstrate an approximate water level. Such points are usually those about which the person describing the level had first-hand knowledge.

"Vague" points are typically points where the level is second hand knowledge, the structure affected is no longer in existence, or the level reached is stated as being an estimate.

"No Point" is used to designate flood events at a reference point for which commentary is available, but not in sufficient detail to allow a water level to be determined.

A preliminary analysis was made of these water level reference points. The resulting information was used as a guide to the field survey crew and is summarized in Table 3. In addition, a "Field Guide" was produced which summarized the findings of the interviews and archival research. The report showed the

TABLE 3

PRELIMINARY RANKING OF POINTS

Pt #	1923	1936	1940	1950	1953	1954	1959	1961	1963	1970	1973	1979	1986	ICE SCAR	P&R #	Pt #	Control
1					G	V		V	A			G				1	Horz Vert
2	V				V											2	Horz Vert
3	A															3	Horz Vert
4					R	R						G			1	4	Horz Vert
5				G								R			2	5	Horz Vert
6	V											G			3	6	Horz Vert
7	V											R			4	7	
8												R			4	8	Vert
9				G								G			6	9	Vert
10	V											G			7	10	Vert
11				G								G			8	11	Vert
12												V			9	12	
13	A															13	Horz Vert
14	A											R			22	14	Horz Vert
15	V					R		V								15	Horz Vert
16						R								R		16	Horz Vert
17												G			23	17	
18												G			24	18	Vert
19	R											A				19	Horz Vert
20																20	Vert
21	A					A	A	A		R						21	Horz Vert
22														G		22	
23						A		A				R			12	23	Vert
24												G			13	24	Vert
25												R		G	14	25	Horz Vert
26														G		26	Horz Vert
27	A											A				27	Horz Vert
28			V							V						28	
29														G		29	Horz Vert
30										A		G			16	30	Vert
31	V											G			17	31	Horz Vert
32	R			A			G	G		G		G				32	Horz Vert
33										V		G			18	33	Horz Vert
34	R										R					34	Vert
35												G			19	35	
36	A															36	Horz Vert
37												G	V		20	37	Vert
38										R						38	Horz Vert
39												R			25	39	
40										R						40	
41												R	A		21	41	
42	Y				A							A	V			42	Horz Vert
43	R									V						43	
44														G		44	Vert
45	Y													G		45	Horz Vert
46	A															46	Horz Vert
47														G		47	Vert
48		V						V		V						48	Horz Vert
49					R							G			28	49	Vert
50				Y												50	
51	Y			A	V	A		A				G			29	51	Vert
52												G				52	Vert
53	Y			Y	G			A	A							53	
54								Y								54	
55								R								55	
56								R	R	R	R					56	

locations of the known flood levels and included a description of the reference points, pictures of the original building affected or flood lines and pictures of the present structures. The document listed a total of 56 reference points for location by the field survey crew. The "Field Guide" is part of the supplementary information provided to the Technical Committee as part of this study (WMS, 1989).

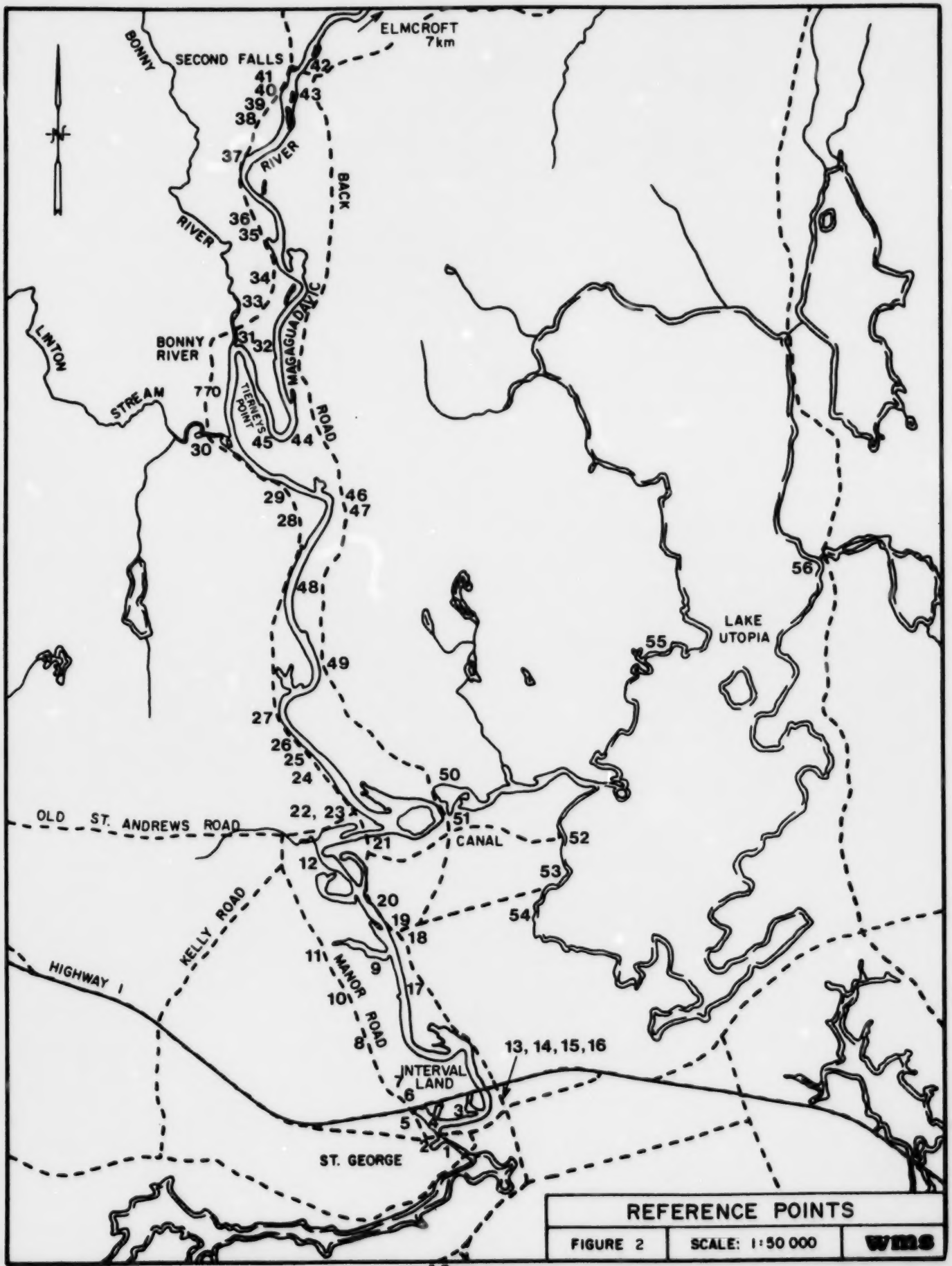
The Terms of Reference for this study required that a total of 40 points were to be located as part of the field program; these were selected from the initial list described above (Table 3). The ranking of the points determined which were the most important points to be located by the field surveyors so that the most complete coverage of the River valley and the years of flooding could be provided. The approximate location of the reference points is shown in Figure 2.

3.3.2 Flood Descriptions

In this section, four of the major flood events for which data points exist are described. This provides a background of information about the major floods events in the Study Area.

3.3.2.1 Flooding of 1923

In 1923 the Magaguadavic River valley experienced the highest flood on record. The flood was a result of 100 mm of rain falling in a 36 hour period on a saturated snowpack which was estimated at 60 to 120 cm in depth. This caused rapid melting and heavy runoff. The flow at the Elmcroft hydrometric gauge was not recorded because the gauge was inaccessible and could not give an accurate reading due to the level of water in the River valley. It was estimated that the flow reached nearly 1700 m^3/s (Smith, 1923), although this estimate has been discounted and is


ELMCROFT
7km
SECOND FALLS
BONNY
RIVER
BACK
RIVER
MAGAGUADAVIC
ROAD
TIERNEY'S POINT
BONNY RIVER
LINTON
STREAM
LAKE UTOPIA
OLD ST. ANDREWS ROAD
CANAL
KELLY ROAD
HIGHWAY 1
MANOR ROAD
INTERVAL LAND
13, 14, 15, 16
ST. GEORGE
REFERENCE POINTS
FIGURE 2
SCALE: 1:50 000
WRS

no longer included in the historic streamflow summaries (IWD, 1987). In Chapter 4, the significance of the estimate of the 1923 flow is discussed with reference to the determination of the 1 in 100 year open water flow elevations.

The report describing the flood states that all the flow in the River was able to pass between the abutments of the old highway bridge located above the dam (Smith, 1923). A drop in water level through the bridge appears to be about 1200 mm in the old photographs. This information was used to estimate the peak flow in the River during the flood.

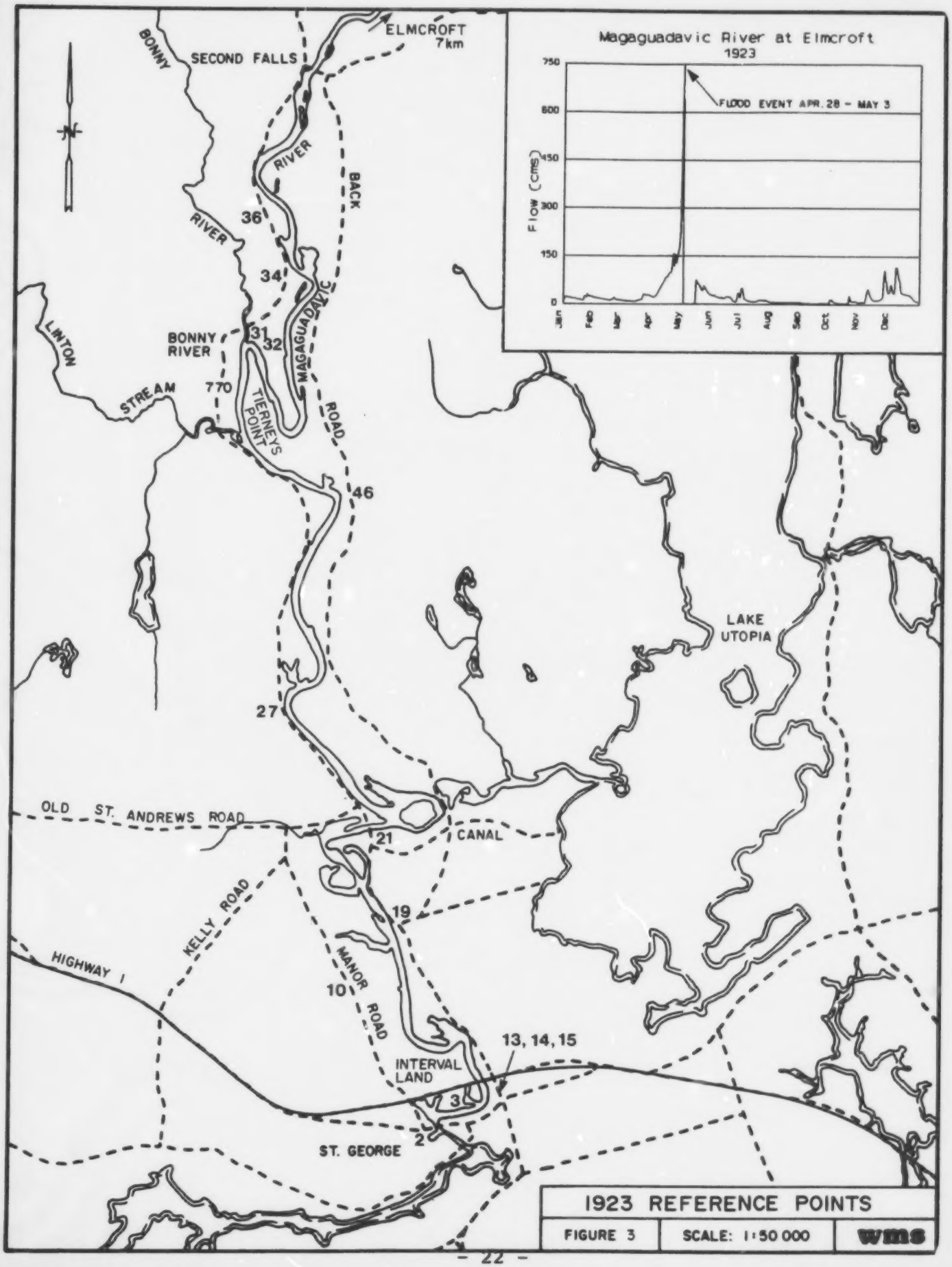
Kindervater (1985) reported that the 1923 flood resulted in great loss of lumber and pulpwood. Telephones in the area were out of service. At Upper Trout Brook, the bridge was lifted off the abutments but was secured by ropes, preventing it from floating away. Several homes were flooded and farm animals were driven to higher ground. The bridge at Lower Trout Brook was flooded and at Flume Ridge, the roads were inundated. A portion of the dam at MacDougall Lake was washed out and a covered highway bridge at Lee Settlement was carried away. Bridges at Second Falls and Bonny River were destroyed. Families in the communities were forced to vacate their homes. The highway between Bonny River and St. George was inundated and several cottages on Lake Utopia were flooded. At St. George, heavy damage was sustained to the upper highway bridge. Log booms at St. George broke and lumber was carried out to sea. The damage to homes in St. George was extensive; 25 families were forced to leave their homes.

The property damage in the 1923 flood was estimated to exceed $3 million (1983 $). The principal losses were incurred by the Bonny River Lumber Company and St. George Pulp and Paper.

The flood of 1923 is still well known by residents of the area. Some of the older residents provided first-hand accounts of the flood event. Numerous pictures were taken of the event, and many residents made copies available. Some of the photographs showed structures which are still standing today, thus allowing fairly reliable estimates of the water levels attained during the flood.

A total of 14 water level points were surveyed, although 21 were recorded for the 1923 event (Table 3). From these points a reasonable estimate of the water levels in the valley during the flood were obtained. Figure 3 shows the approximate location of the points located and the hydrograph for the River in 1923. The elevations of the points as determined by the field survey confirms that the 1923 event was higher than any other flood on record and were about 1 m higher than the 1979 event. The level shows a consistent slope along the length of the River valley, which would indicate the River was not blocked by ice but flow was controlled at bridges or at the dam, the exact point of flow control is not known. The ice out date on Lake Utopia was reported to be May 1, 1923, which was the first day of the flooding. There is no indication of the ice out date on the River, but reports do not mention any ice jams.

Figure 4 shows the location and relative elevation of the points which were found. The determination of the envelope of maximum flooding considers the relative reliability of each point found and the degree of certainty which can be placed on it.


Magaguadavic River at Elmcroft
1923
FLOOD EVENT APR. 28 - MAY 3
Flow (cms)
750
600
450
300
150
0
ELMCROFT
7km
SECOND FALLS
BONNY
RIVER
BACK
RIVER
36
34
MAGAGUADAVIC
31
32
BONNY
RIVER
LINTON
STREAM
770
TIERNEYS
POINT
ROAD
46
27
LAKE
UTOPIA
OLD ST. ANDREWS ROAD
21
CANAL
19
KELLY ROAD
HIGHWAY 1
MANOR ROAD
10
13, 14, 15
INTERVAL
LAND
3
2
ST. GEORGE
1923 REFERENCE POINTS
FIGURE 3
SCALE: 1:50 000
wms

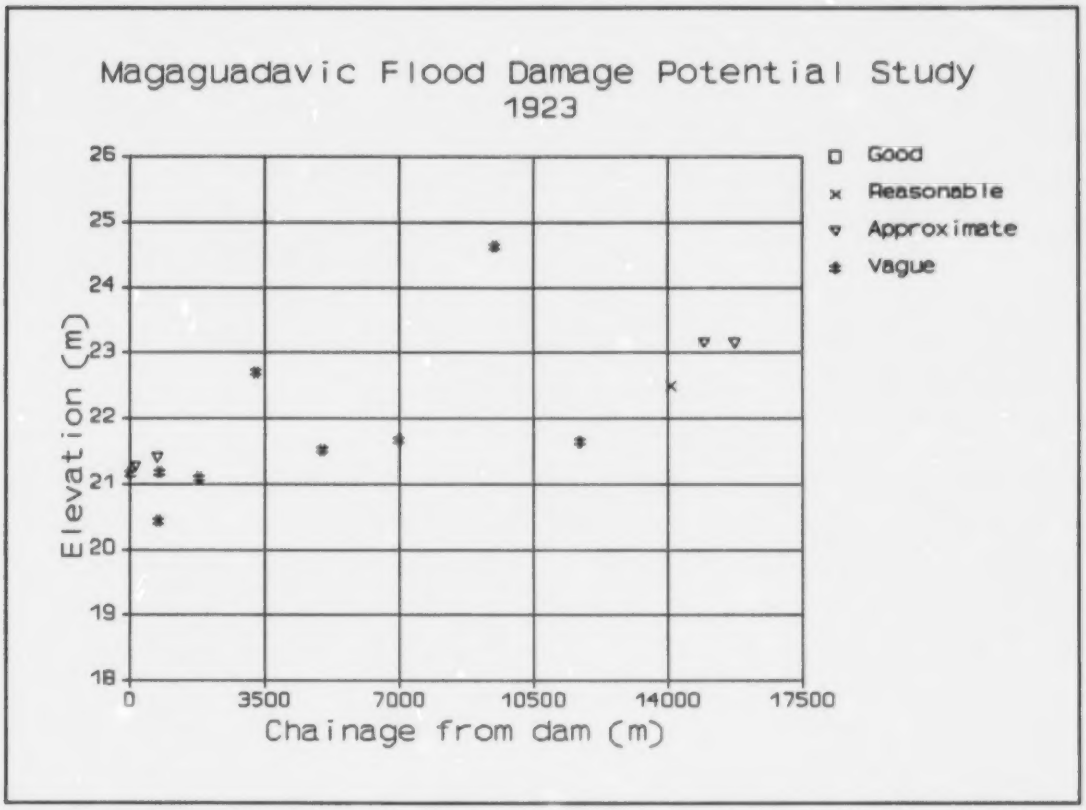


Figure 4

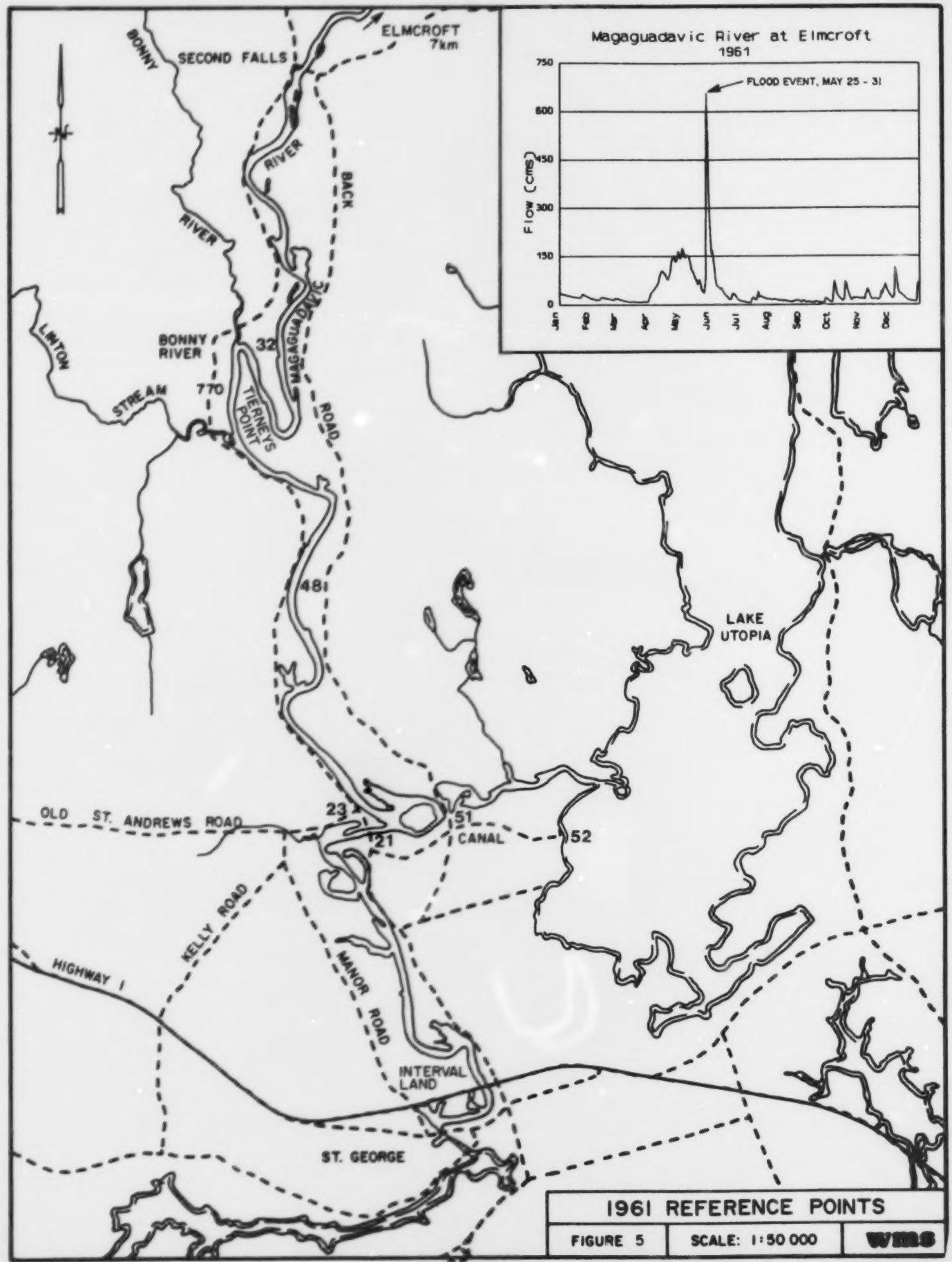
1923 Water Levels

3.3.2.2 Flooding of 1961

In the period of May 25 to 31, 1961 a severe extra-tropical storm brought nearly 125 mm of rain to the Magaguadavic River Basin resulting in a late spring flood. At the Elmcroft hydrometric gauge, a peak daily flow of 657 m^3/s was recorded, the third highest on record. Figure 5 shows the approximate location of the points which were found for the 1961 flood, and also the hydrograph for 1961.

Reports in the Saint Croix Courier (June 1, 1961) and in Kindervater (1985), describe the effects of the 1961 flood. Crops were ruined by the heavy rains and flood waters. Dwellings were damaged, and highways and rail lines were washed out at several places. Bonny River and Second Falls were isolated when highways became inundated; twelve families in this area were forced to evacuate their homes. At Lake Utopia, about one-half of the summer cottages were either flooded or moved off their foundations. Many homes in St. George were surrounded by water, basements were flooded and three families were forced to vacate their homes. The mill at St. George was forced to close, and telephone service was disrupted.

Local residents added the comments that the fields were flooded with pulpwood and cattle had to be rescued. The flood was said by some to be the highest since 1923. Some photographs of high water during the event were obtained, and a total of 11 water level points were found (Table 3). Of the points found, elevations for 6 were taken during the field survey and provide an indication of the maximum water level reached during the event. Figure 6 shows the location and relative elevation of the points which were found.


ELMCROFT
7km
BONNY
SECOND FALLS
RIVER
BACK
RIVER
MAGAGUADAVIC
BONNY
RIVER
32
LAWTON
STREAM
770
TIERNEYS
POINT
ROAD
481
LAKE
UTOPIA
OLD ST. ANDREWS ROAD
23
51
21
CANAL
52
KELLY ROAD
HIGHWAY 1
MANOR ROAD
INTERVAL
LAND
ST. GEORGE
Magaguadavic River at Elmcroft
1961
FLOOD EVENT, MAY 25 - 31
FLOW (cms)
750
600
450
300
150
0
1961 REFERENCE POINTS
FIGURE 5
SCALE: 1:50 000
WRB

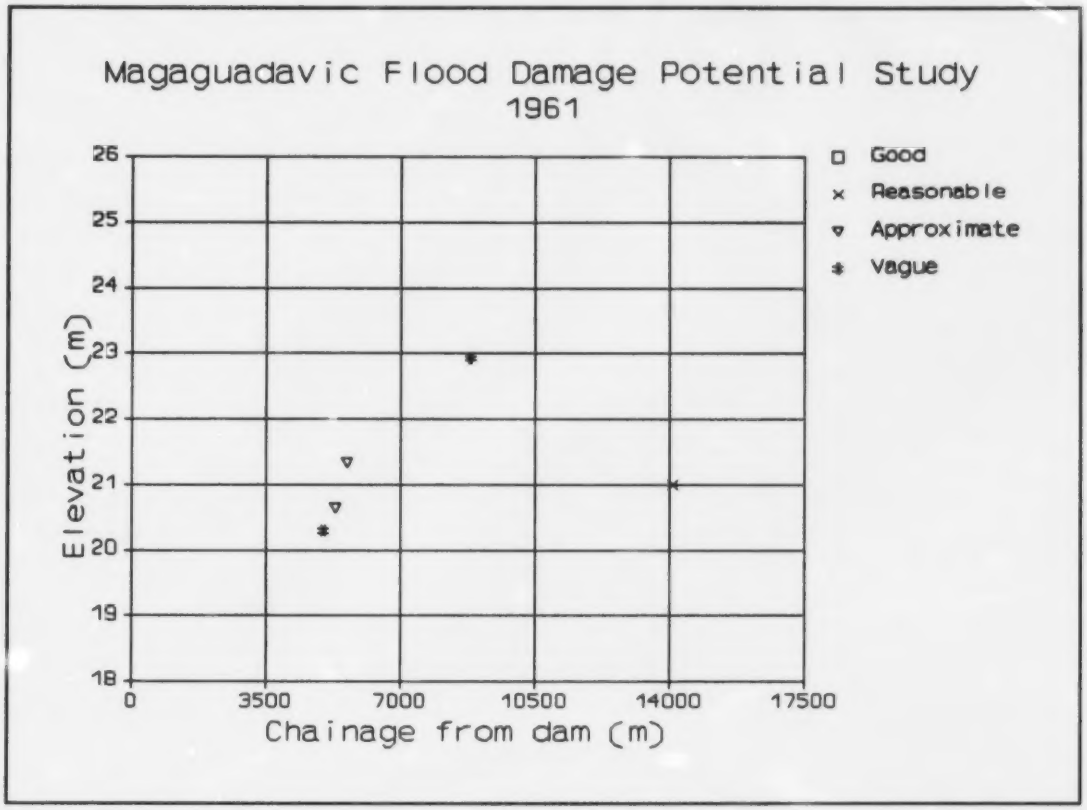


Figure 6

1961 Water Levels

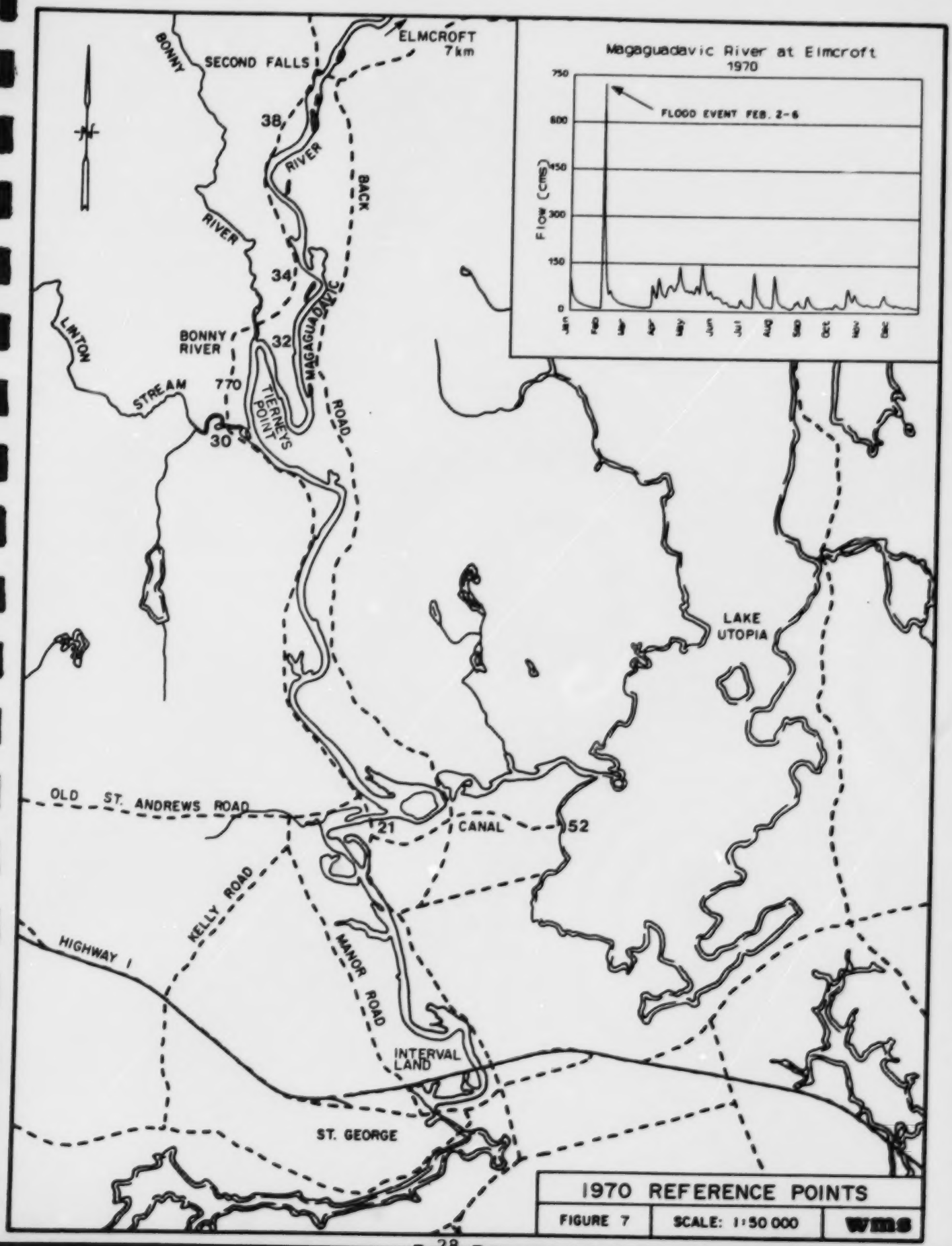
3.3.2.3 Flooding of 1970

Between February 2 and 4, 1970, heavy rain, high temperatures and ice jams caused extensive flooding and damages in the Magaguadavic River valley. The rainfall in the area was recorded at 124 mm during the period. The flow recorded at Elmcroft reached a peak daily flow of 722 m^3/s, which is the second highest on record, exceeded only by the 1923 flow. Figure 7 shows the approximate location of the points which were found for the 1970 flood, and also the hydrograph for 1970.

Reports in the Saint Croix Courier (Feb 5, 1970) and the Saint John Telegraph-Journal (Feb 4, 1970) describe the effects of the 1970 flood. The area from Second Falls to Bonny River suffered extensive damage as a result of the event. Ice jams formed just below the bridge at Second Falls and at Tierney's Point. Bulldozers and tractors were used to clear an estimated 10 kilometre stretch of the road which had been covered by ice to heights of 4.5 to 6 m. The ice and flood waters caused extensive damage to some of the houses in the area, with some being pushed off their foundations and destroyed. About 16 families in the area were affected, with 30 to 40 residents being evacuated during the event.

Downstream of the area affected by the jamming, there were no reports of problems from the high flows. The level at Lake Utopia was reported to be high, but less than during other years. No flooding was reported in St. George.

Photographs were obtained which depict the limit of the high waters and ice during the event were obtained; the newspapers also show photographs of the height of ice on the roads. Figure 8 shows the location and relative elevation of the points which were found for the 1970 flood. A total of 10 water level points were found. Of these, elevations for 6 were taken during the


Magaguadavic River at Elmcroft
1970
FLOOD EVENT FEB. 2-6
Flow (cms)
750
600
450
300
150
0
ELMCROFT
7km
SECOND FALLS
BONNY
RIVER
38
34
32
30
BACK
RIVER
MAGAGUADAVIC
RIVER
BONNY
RIVER
LINTON
STREAM
770
TIERNEYS
POINT
ROAD
LAKE
UTOPIA
OLD ST. ANDREWS ROAD
21
CANAL
52
KELLY ROAD
HIGHWAY 1
MANOR ROAD
INTERVAL
LAND
ST. GEORGE
1970 REFERENCE POINTS
FIGURE 7
SCALE: 1:50 000
wms

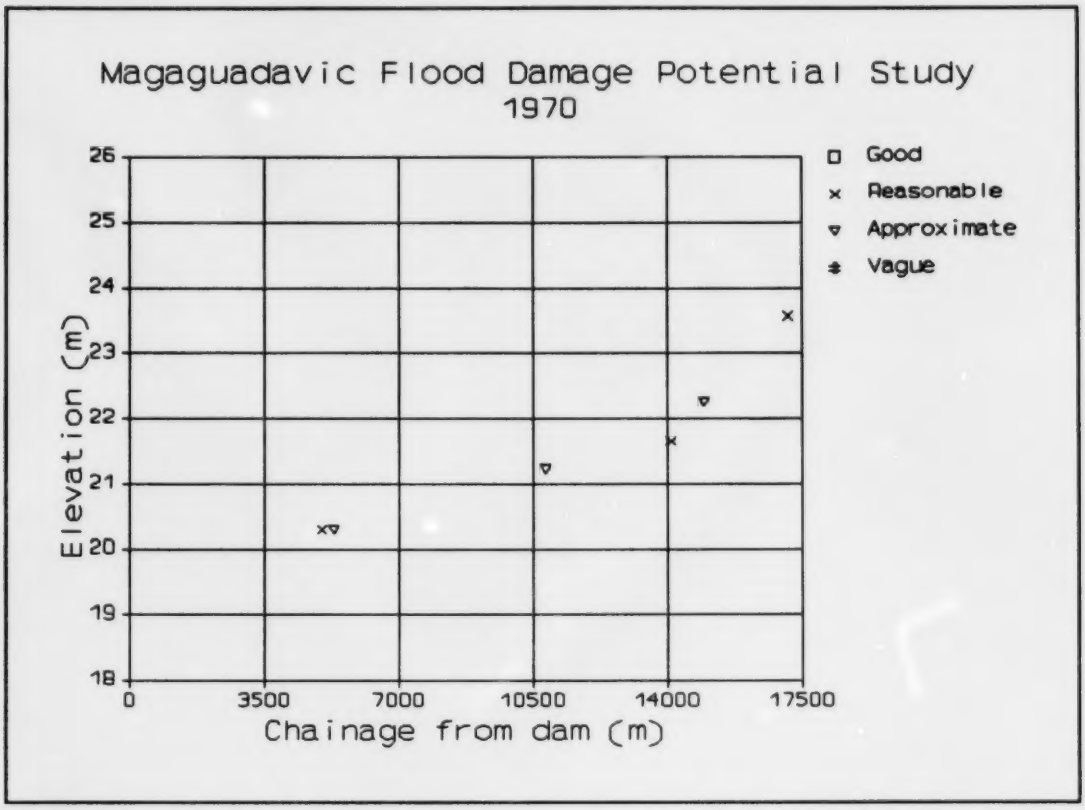


Figure 8

1970 Water Levels

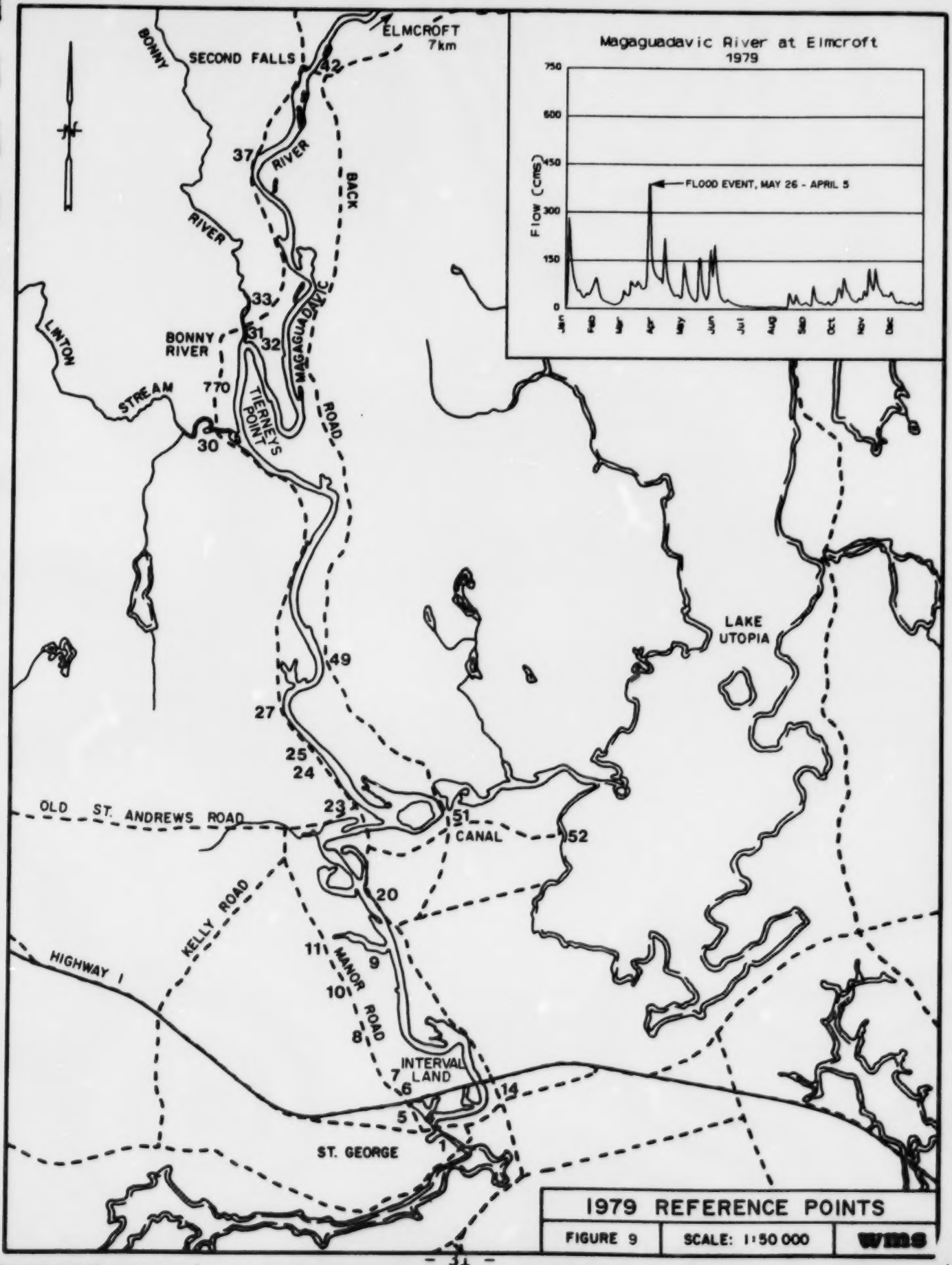
field survey and provide an indication of the maximum water level reached during the event.

3.3.2.4 Flooding of 1979

A fourth major flood on the Magaguadavic River occurred between Second Falls and St. George during March 26 to April 5, 1979. The flood was caused by mild temperatures and rain, which resulted in high runoff and some ice jams. The flow recorded at Elmcroft reached a peak daily flow of 390 m^3/s, which is the sixth highest on record. There was an ice jam at Second Falls although this was not the cause of the flooding in the Study Area. Bulldozers were required to clear the piled up ice from the road. Figure 9 shows the approximate location of the points which were found for the 1979 flood, and the hydrograph for 1979.

Kindervater (1985) reported that the Bonny River Road was inundated at several locations. At Second Falls, flooding was reported near the church. At Bonny River at least 25 families were forced to leave their homes. The levels on Lake Utopia were reported to be the highest since the flooding of 1961 and several cottages were flooded. In St. George, a number of basements were flooded and some houses were surrounded by water. Sections of Manor Road were inundated between Brunswick Drive and Highway 1, as well as a section of River Avenue near Canal Road.

Shortly after the flood event, the New Brunswick Department of the Environment commissioned an investigation under the auspices of the Canada-New Brunswick Flood Damage Reduction Program to document information on the flood so that the extent of flooding and resultant water levels could be determined (Proctor and Redfern, 1979). The report identified 30 reference locations at which evidence of the flood level could be identified. The elevation at most of the points could not be determined because


ELMCROFT
7km
SECOND FALLS
BONNY
42
37
RIVER
BACK
RIVER
33
31
32
BONNY
RIVER
MAGAGUADAVIC
LINTON
STREAM
770
TIERNEYS
POINT
ROAD
30
Magaguadavic River at Elmcroft
1979
750
600
450
300
150
0
Flow (cms)
FLOOD EVENT, MAY 26 - APRIL 5
LAKE
UTOPIA
49
27
25
24
OLD ST. ANDREWS ROAD
23
51
CANAL
52
20
KELLY ROAD
HIGHWAY 1
11
9
MANOR
10
ROAD
8
INTERVAL
LAND
7
6
14
5
1
ST. GEORGE
1979 REFERENCE POINTS
FIGURE 9
SCALE: 1:50 000
WMS

Geodetic control was not available. The temporary benchmarks used in the study were described so that the elevations could be determined at a later date. However, this was not done until the present study; therefore some of the points and benchmarks from Proctor and Redfern (1979) could not be located due to changes in the area.

The present study investigated all the points identified in the 1979 study, and found that 23 of them useable. An additional 7 points were identified by WMS Associates Ltd., resulting in a total of 30 water level points (Table 3). Of the points found, elevations for 23 were taken during the field survey and provide an indication of the maximum water level reached during the event. Figure 10 shows the location and relative elevation of the points which were found.

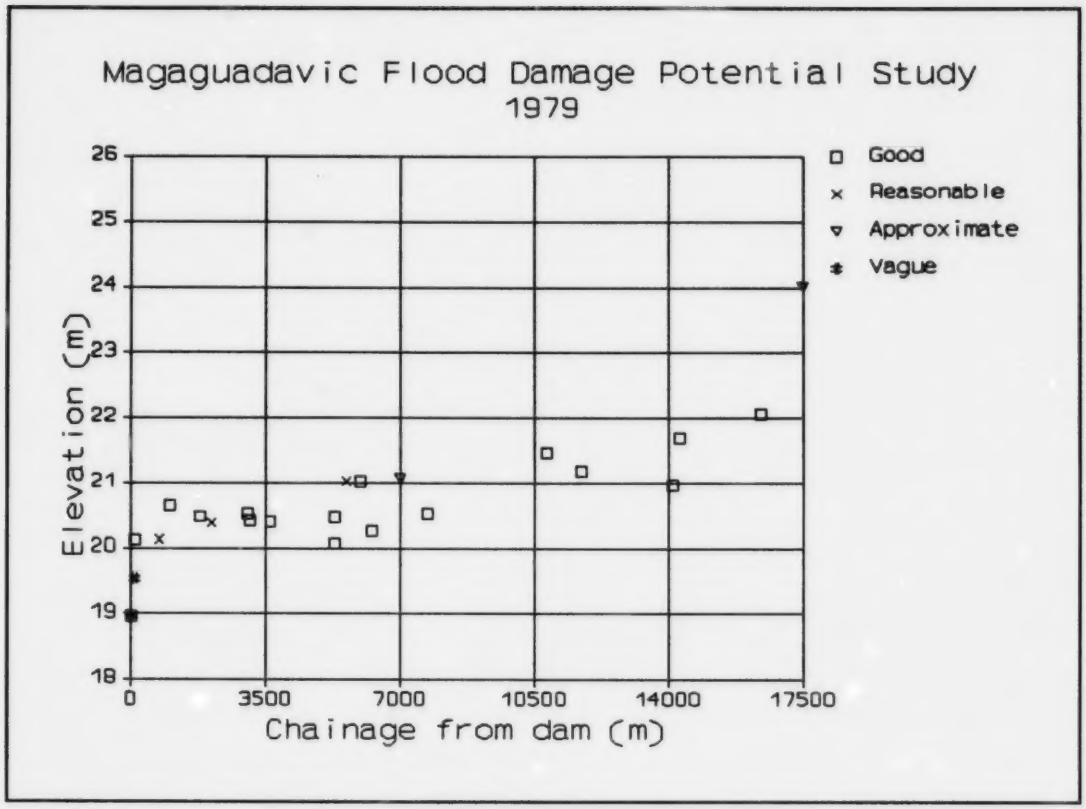


Figure 10

1979 Water Levels

3.3.2.5 Ice Scars

It was shown in Table 1 that ice jams are not usually the main cause of flooding in the Study Area. The flood event in 1970 was caused by a severe ice jam, but in other years the major cause has usually been open water flows. During the normal ice run at spring break up on the River there may be minor jamming at some locations, but the jams usually release before the water levels become excessive.

As part of this study, residents were asked for known locations of ice scars or other physical evidence of flooding. A total of 8 ice scar locations were identified (Table 3). At each location there was usually more than one tree which had been scarred. The field survey found elevations for six ice scar locations. The data confirms that ice scarring does not generally occur during high flood events. The scars which were found appear to be relatively recent, and could post date the 1970 ice jam event. Figure 11 shows the location and relative elevation of the points which were found.

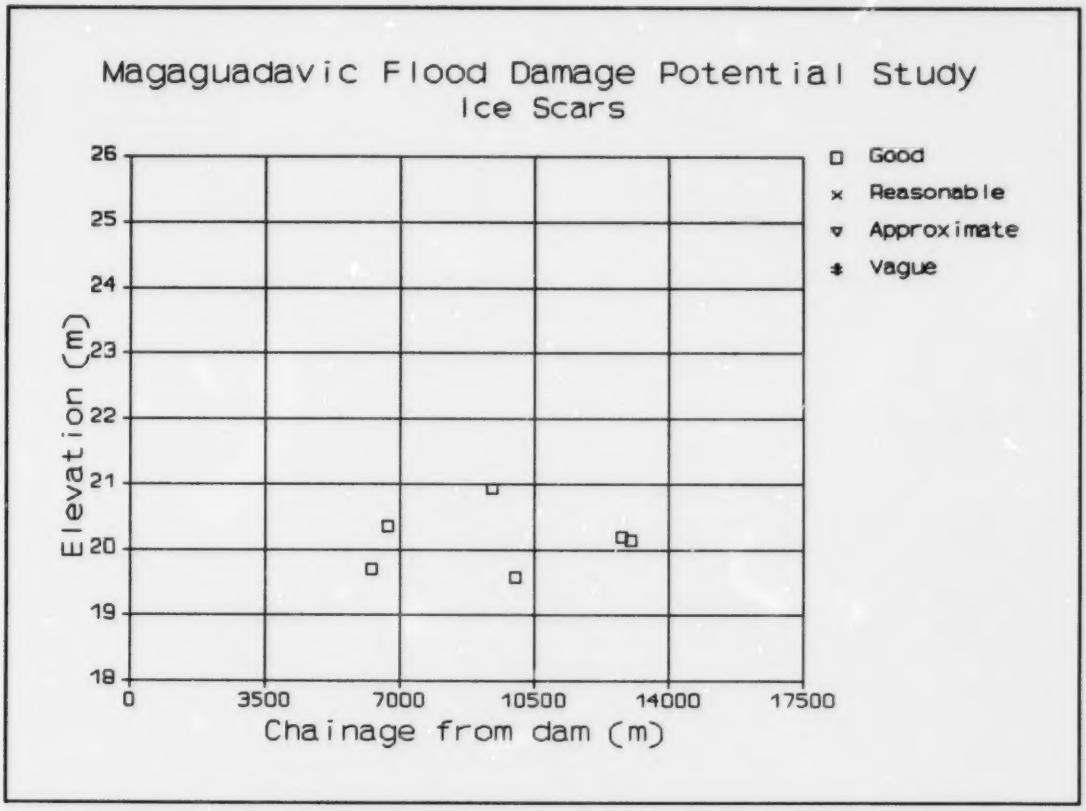


Figure 11

Ice Scar Elevations

3.3.3 Field Survey

The details of the data collected by the surveyors during the field program is included in a separate report which provides the supplementary information for this study (Geoplan, 1989). This includes the field notes taken during the survey and the descriptions of the benchmark locations. Table 4 presents the elevations and locations of the reference points found during the study. These were used to determine the flood levels for flood events identified. The Geodetic Survey of Canada datum was used to determine the elevation of 40 points found during the study. Of these points, the horizontal position was determined for a total of 25 points. For the remaining points, the location was determined by general map reference.

3.3.3.1 Horizontal Control

The horizontal position of a number of the flood level marks was accomplished by establishing New Brunswick stereographic grid coordinates for points identified. The New Brunswick coordinates were obtained by closed traverses which were run between various New Brunswick monuments in the area using a Wilde T-1600 total station and target system. The traverse precisions ranged from 1/7400 to 1/27500. The coordinates of control points are shown in the traverse computation in the supplementary data (Geoplan, 1989) along with the coordinates of identified water level marks located by side shots from the main control. All control hubs are iron bars or nails set in asphalt and are considered semi-permanent.

3.3.3.2 Vertical Control

None of the New Brunswick monuments in the area were considered adequate for vertical control for Geodetic datum. Consequently all elevations were established using a combination of spirit

Table 4

Elevation and Location of Reference Points

Point	Northing (m)	Easting (m)	Elevation (m)
1	647710.578	274107.290	19.88
2	647761.000	274101.480	20.14
3	647827.555	274248.152	21.27
4	647850.450	273913.046	19.98
5	647884.497	273855.031	19.94
6	648116.578	273747.217	20.65
8			20.39
9			20.29
10			22.85
11			20.42
13	648041.250	274774.932	21.40
14	648089.668	274705.689	20.14
15	648122.395	274698.428	20.28
16	648191.884	274721.828	20.42
19	649992.928	273763.488	22.70
20			20.41
21	650940.427	273432.779	20.30
23			21.03
24			21.03
25	651774.077	272912.816	19.71
26	652187.243	272565.218	20.36
27	652347.678	272534.832	20.76
29	654732.184	272680.075	19.32
30			21.22
31	656424.627	272224.065	21.19
32	656340.541	272575.858	21.79
33	656684.017	272552.728	21.70
34			23.16
36	657586.278	272490.563	23.23
37			22.45
38	658806.551	272677.109	23.57
42	659147.416	272894.249	24.02
44			20.15
45	655352.318	272530.510	20.20
46	654641.778	273224.689	24.63
47			20.93
48	653737.640	272931.925	22.93
49			21.10
51			20.57
52			19.89

levelling and trigonometric levelling based on bench marks established by Geodetic Survey of Canada.

Spirit level elevations were established by double levelling from Geodetic bench marks to points 22639 (N.B. Monument), 1040 and 1001 (Figure 12). Trigonometric levelling using both forward and backward sightings with the T-1600 system was carried out in the St. George area using the above points for closure. The closing errors in this network of trigonometric levelling in the vicinity of St. George were all less than 20 mm.

The T-1600 is a modern electronic station having an internal program to compute elevation differences corrected for both curvature and refraction.

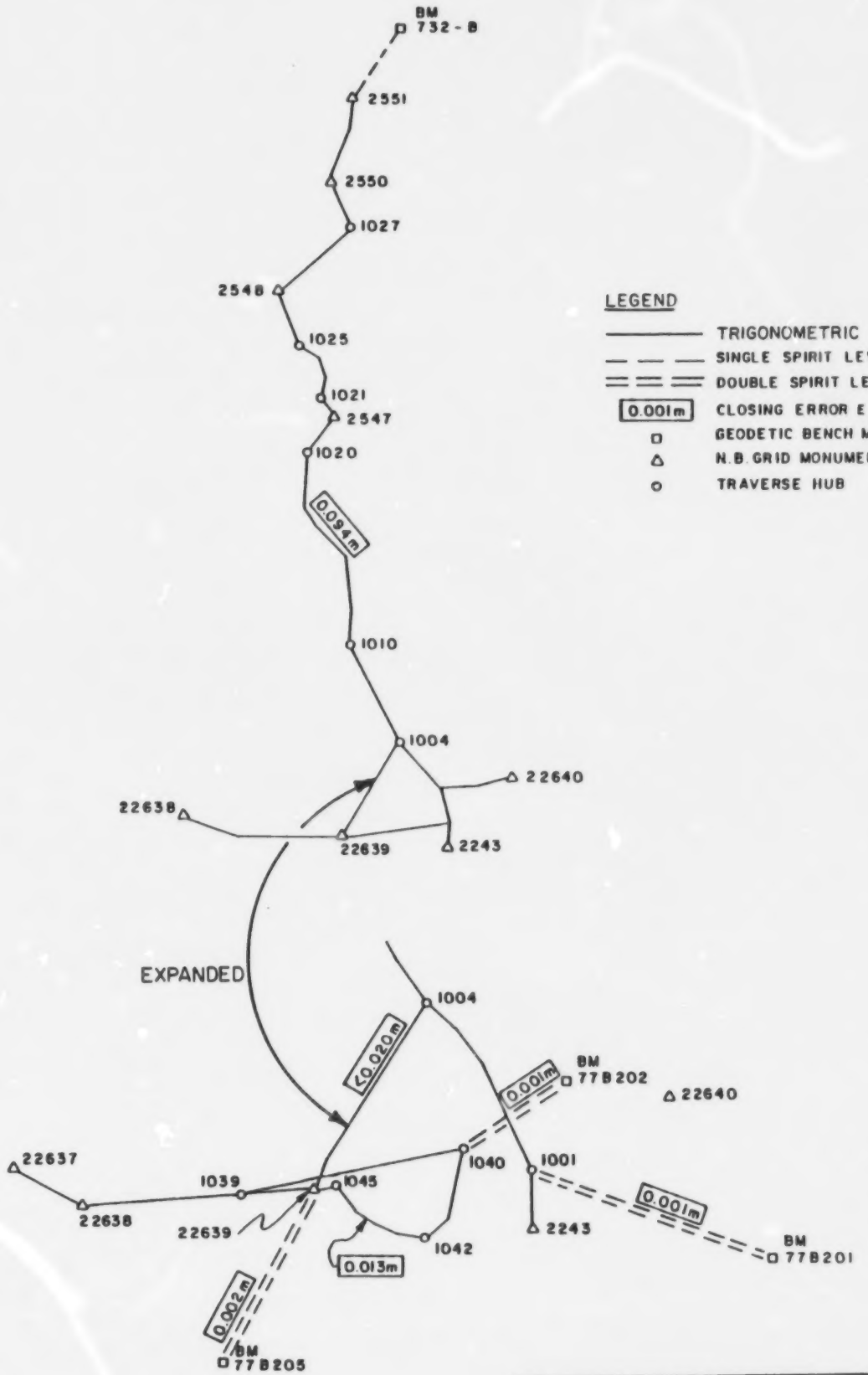
A second loop of forward and reverse trigonometric levels was run from point 1004 northward up the Magaguadavic River to N.B. Monument 2551. The maximum elevation difference between forward and reverse elevation was 35 mm. These elevation differences were averaged and used to compute elevations for the control points.

Finally, N.B. Monument 2551 was spirit levelled to a previously established DNR bench mark and a closure was established for the entire loop of 94 mm. This error was then distributed over the 17 km loop.

Supplementary bench marks were set for future reference by spirit levelling from the control network. A list of bench marks established complete with sketches is provided with the supplementary data (Geoplan, 1989). Figure 12 shows a schematic of the survey route and the closures obtained. All bench marks are considered semi-permanent with a life expectancy of about 5 years.

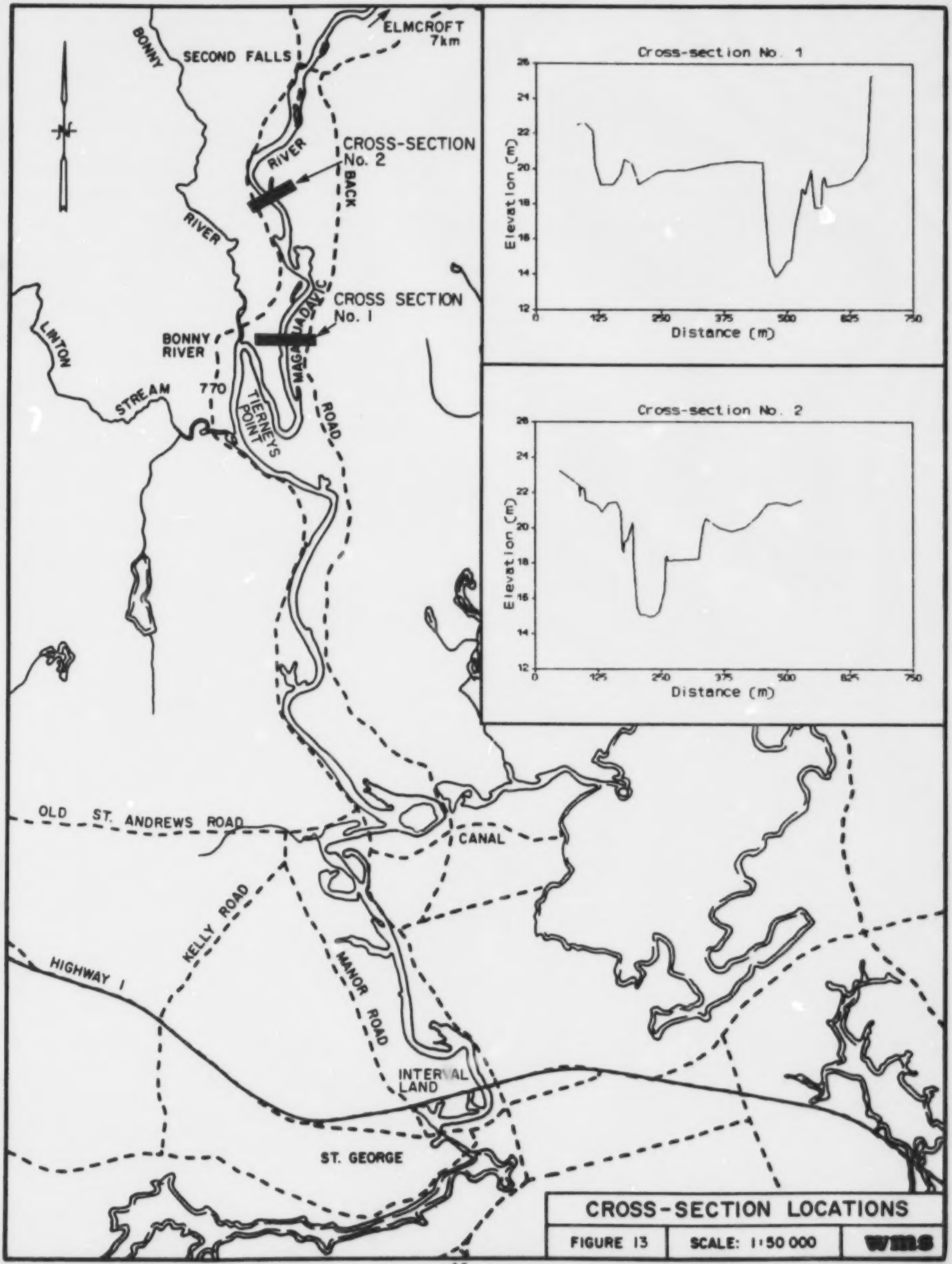
3.3.3.3 River Cross-sections

Two river cross-sections were surveyed. These cross-sections were located with respect to the horizontal and vertical control established for the project. The locations of the cross-sections are shown on Figure 13.



BENCH MARK CIRCUIT SCHEMATIC

FIGURE 12	SCALE: 1:50 000	WMS


ELMCROFT
7km
SECOND FALLS
BONNY
RIVER
CROSS-SECTION
No. 2
BACK
RIVER
CROSS SECTION
No. 1
BONNY
RIVER
LINTON
STREAM
770
TIERNEYS
POINT
MAGAZINE
ROAD
Cross-section No. 1
Elevation (m)
Distance (m)
Cross-section No. 2
Elevation (m)
Distance (m)
OLD ST. ANDREWS ROAD
CANAL
KELLY ROAD
HIGHWAY 1
MANOR ROAD
INTERVAL
LAND
ST. GEORGE
CROSS-SECTION LOCATIONS
FIGURE 13
SCALE: 1:50 000
WMS

4.0 HYDROTECHNICAL STUDIES

Hydrotechnical studies were carried out in order to make a comparison between the water levels of past flood events, as described in Chapter 3, and the 1 in 100 year open water flood level. This comparison was made at two locations in the Magaguadavic River Valley:

- between Second Falls and Bonny River; and
- at the dam at St. George.

The design flows for the 1 in 100 year event were estimated at each of these locations using regional flood frequency methods and compared to the results of single station frequency analysis. The flow on the Magaguadavic River is gauged at Elmcroft (Station 01AQ002), approximately 7 km upstream of Second Falls, and this gauge record was used in the comparison.

The hydraulic calculations in the upstream portion of the Study Area are based on cross-sectional information collected as part of the field program at two locations (Figure 13) on the River:

- between Second Falls and Bonny River, approximately 2500 m downstream of Second Falls; and
- near Bonny River, approximately 1800 m downstream of the first cross-section.

The hydraulic calculations to determine the water level in the vicinity of the dam at St. George were based on the discharge capacity of the spillway structures at the dam and the relationship between discharge and water level.

4.1 Open Water Flow Magnitude

The flow for the 1 in 100 year open water event was determined for two locations on the Magaguadavic River, corresponding to the locations at which water levels are to be determined. The flow in the River is not gauged at these points, so the flood flows were estimated using regional regression or proration techniques.

4.1.1 Flow Data

The hydrometric gauge at Elmcroft provides a long term record which can be used in the single station flood frequency analysis. The gauge was established in 1917 and operated until 1933. It was re-established in 1944 and has provided a continuous record since. There is some upstream regulation on the Magaguadavic River at Magaguadavic Lake. It has been assumed that this does not exert a large degree of influence on the flood discharge of the River. The flood of record on the Magaguadavic River occurred in 1923. At that time the gauge was inaccessible for a number of days and no reading of the water level could be taken. It was subsequently estimated that the flood discharge reached a peak flow of 1700 m^3/s (Smith, 1923). The estimate was based on hydraulic calculations of the flow at the highway bridge in St. George. The estimates of flow have since been disputed and are no longer included in the historical streamflow summaries (IWD, 1987). The flow estimated by Smith (1923) was for the Magaguadavic River below St. George. A more realistic estimate of the flow at the Elmcroft gauge would be about 1300 m^3/s based on the ratio of drainage areas.

The estimated magnitude of the 1923 flood is higher than any other flow recorded on the River, being up to double the next highest recorded event (IWD, 1987). The single station flood frequency analysis on the flow at Elmcroft gave a 1 in 100 year

flow estimate of 571 m^3/s (IWD and DMAE, 1987). The single station flood frequency analysis was performed again in order to examine the sensitivity of the 1 in 100 year flow to the estimate of the 1923 flow as shown in Table 5.

Table 5
Sensitivity of 1 in 100 year Flow to 1923 Estimate

1923 Estimate (m^3/s)	1 in 100 year Flow (m^3/s)
---	571
850	646
1000	665
1500	720
1700	739

This comparison illustrates that the 1 in 100 year flood estimate is quite sensitive to the estimate of the 1923 flood. The maximum and minimum estimates of the 1 in 100 year flows will be used in the comparison with the regional regression methods discussed in the following sections.

The flows on the River are usually reported as the mean daily flow. For peak events, it is important to know the instantaneous maximum flow, which can be substantially higher than the mean flow. On the Magaguadavic River, the ratio of the peak flow to mean flow is estimated at 1.08 (IWD and DMAE, 1987).

4.1.2 Drainage Areas

Both the regional regression method and the proration method of determining flow on an ungauged basin depend on an estimate of the drainage area. Table 6 shows the drainage areas which were estimated using 1:50,000 topographic mapping for the areas between St. George and Elmcroft. The Elmcroft drainage area is that reported by IWD (1987).

Table 6
Magaguadavic River Valley Drainage Areas

Basin	Area (km^2)
Elmcroft*	1420
Bonny River	1594
St. George	1829

*Source: IWD (1987)

4.1.3 Flow Estimates

The regional regression method uses equations developed for each region of the Province which relate the drainage basin area to the design flows for different return periods (IWD and DMAE, 1987). Some of the equations also employ an estimate of the mean annual precipitation (MAP) to improve the estimate of flow. The equations which are examined for this study are:

- the equation for the entire Province;

- the equation for the entire Province with the mean annual precipitation estimate; and

- the equation for the southern basins in the Province.

The proration method determines the flood flow at an ungauged site; it is calculated by multiplying a known flood for a similar gauged basin by the ratio of drainage basin areas. This method is based on the following assumptions:

- basins are similar in area (plus or minus 20 percent);

- they have similar land use and physiography; and

- they are located in the same general vicinity.

The locations for which flows were to be determined were both located on the Magaguadavic River downstream of the hydrometric gauge and have similar sized drainage basins; the proration technique is therefore applicable.

The use of these methods to estimate the flow resulted in a wide range of variation the estimate of the 1 in 100 year open water flow as shown in Table 7. The selected values for the 1 in 100 year flow are those represented by the Provincial Regression equation using drainage basin area only. These flows fall close to the values obtained using the proration method including the 1923 flow. The regional equations indicate that the single station flood frequency analysis at Elmcroft may be underestimating the magnitude of the 1 in 100 year flood.

The flow estimated from the equation for the southern basin was not used because the Magaguadavic River Basin drainage area exceeds the maximum range for which the equation is valid. The

inclusion of the mean annual precipitation in the Provincial regression equation showed an increase in the flow but without a significant decrease in the standard error of the estimate. The result also depends on accurate determination of the mean annual precipitation. Therefore, the flows selected were those obtained using the Provincial equation based on drainage area only.

Table 7

Comparison of Open Water Flow Estimates

Method	Near Bonny River (m^3/s)	St. George (m^3/s)
Regression Equations:		
Province with DA	**736**	**876**
Province with DA & MAP	828	992
Southern Basins with DA	992	1189
Proration:		
Without 1923	601	736
Including 1923	778	952

Note: MAP = Mean Annual Precipitation
DA = Drainage Area

The values which will be used in calculations are the maximum instantaneous flows, obtained by increasing the 1 in 100 year mean daily flows as determined by the Provincial equation given above by a factor of 1.08, as follows:

Bonny River 1 in 100 year flow: **795 m^3/s**
St. George 1 in 100 year flow: **946 m^3/s**

4.2 Flood Stage Estimates

4.2.1 St. George Dam

The dam at St. George was constructed to produce head for a hydroelectric plant about the turn of the century. A pulp and paper mill was established on the site prior to this, but has since ceased to operate. The dam was raised by 1.5 m in 1950 by the St. George Pulp and Paper Company to take advantage of additional storage on Lake Utopia. The St. George Pulp and Paper Company and all of their water rights were purchased by the K.C. Irving Co. in the early 1960's.

The details of the construction of the dam, its discharge capacity and other operational characteristics are not available. It appears that only preliminary layouts for the dam remain in existence. Estimates of the required parameters have been made for the purposes of this study based on field measurements and existing information.

4.2.1.1 Discharge Curves

The physical structure of the dam includes a 58 m long overflow section with a sill elevation at 17.5 m. There are three gates with sill elevations of 16.0 m. The gates are each 3.7 m wide and are closed by removable stoplogs each of which are 200 mm thick. Using this data obtained from field measurements and available drawings of the site layout, an estimate of the discharge was obtained for the dam. The estimate of discharge is made with the stoplogs removed and in place, to allow a comparison of the peak water level which would be attained if the logs were not removed during a flood. The discharge curve is shown in Figure 14 and is based on an assumed coefficient of discharge of 1.84.

The general equation used to estimate the discharge was:

$$Q = Cd \cdot L \cdot (Elev - Sill)^{1.5}$$

where Q is flow (m^3/s)
Cd is discharge coefficient
L is the weir length (m)
Elev is the water level (m)
Sill is the sill level (m)

For the dam at St. George, the following equations were used:

$$Q = 103.8 \cdot (Elev - 17.5)^{1.5} + 20.2 \cdot (Elev - 16.0)^{1.5}$$
(stoplogs removed)

$$Q = 124.0 \cdot (Elev - 17.5)^{1.5}$$ (stoplogs in place)

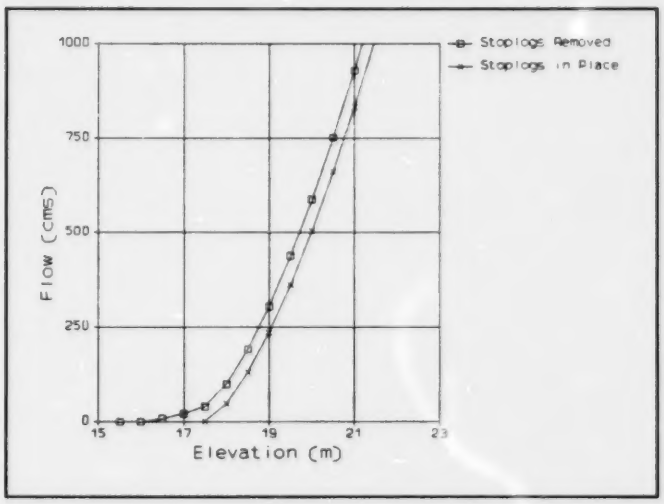


Figure 14

Discharge Curves for St. George Dam

4.2.1.2 Storage Volume Estimates

The volume of storage available in the headpond of the dam will influence the discharge at the dam. The normal operating range of the dam is between 16 m and 18 m, with an available storage of 21.5 Mm^3 (H. Hatten, pers. comm.).

High flows will tend to be attenuated and the peak will be delayed as the inflow fills up any available storage. There is no detailed volume-elevation curve available for the storage in the headpond of the dam at St. George, but estimates were made using available topographic information and estimates of total storage obtained from the plant operator. Table 8 gives the relationship of elevation to storage volume which has been assumed for this study.

Table 8
Storage Volume for St. George Dam

Elevation (m)	Area (km^2)	Storage (Mm^3)
16	0.0	0.0
18	12.9	16.1
20	17.5	46.5

4.2.1.3 Water Level Estimates

The water levels at the dam at St. George which would result from a 1 in 100 year open water flood are estimated using the discharge curve developed for the dam (Figure 14). It has been

assumed that there would be no generation of hydroelectric power at the time of the flood, so all flow would be over the dam. It has also been assumed that the stoplogs at the gate section of the dam would be left in place. Although it is the operational policy to remove the stoplogs whenever there are high flows on the River, it is conceivable that a situation could arise where the stoplogs cannot be removed before the peak of the flood. Such a situation was reported to have occurred during the 1950 flood, the first flood which occurred after the dam was raised. These assumptions will provide a worst case scenario for the determination of the 1 in 100 year open water flood levels.

The routing effect of the storage upstream of the dam was examined to estimate the possible attenuation of the flood peak and delay of the outflow. The calculations were made using an in-house flood routing computer program developed by **WMS**. A typical output from the flood routing model showing inflow and outflow for the 1 in 100 year flood with stoplogs in place is shown in Figure 15. The analysis also examined the effect of removal of the stoplogs on the results, as well as the sensitivity of the results to a 10 percent variation in the estimated value of flow. The results are summarized in Table 9.

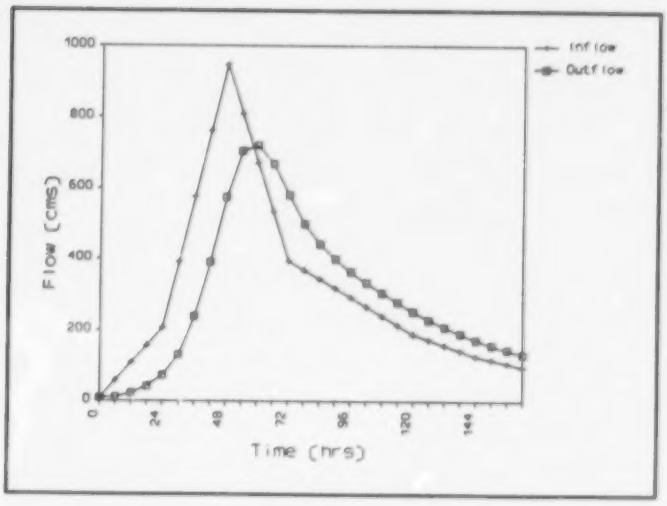


Figure 15

Flood Routing at St. George Dam

Table 9

Comparison of Routing Results

	Water Level with Stoplogs	
	In Place (m)	Removed (m)
Q_{100}	20.7	20.5
Q_{100} + 10%	21.0	20.7
Q_{100} - 10%	20.5	20.2

The water level resulting from the 1 in 100 year flood is therefore estimated to be at Geodetic elevation **20.7 m.** The water level is sensitive to the estimate of the flood peak, and a variation of 10 % on the peak flow was found to vary the water level by about ± 0.3 m. The routing with and without the stoplogs in place shows that the level would be reduced by about 0.3 m by the removal of the stoplogs.

The 1979 flow profile was used to approximate the slope of the water surface in the area upstream of the dam. Based on this, it is estimated that the backwater influence of the control in the lower reaches could extend up as far as Second Falls for a high flow event such as the 1 in 100 year flood.

4.2.2 Magaguadavic River Flow Profile (Bonny River Area)

The profile of the River between Second Falls and Bonny River was estimated using the HEC-2 program to calculate the water surface profile in the reach. As part of the field program, cross-sections were taken at two locations along the River, as shown on Figure 13. These were chosen to be representative of the River in this area. Water level measurements were also taken at the time the cross-sections were taken. The Inland Waters Directorate, Environment Canada, was contacted to obtain the flow at the Elmcroft hydrometric gauge at the time of measurement of the water level. Table 10 summarizes the water levels which were recorded during the field program at the cross-section locations, as well as other locations on the River.

Table 10
Magaguadavic River Water Levels, November 1988

Point[1]	Date	Water Level (m)	Flow[2] (m^3/s)
2	Nov 18	17.96	53.3
3	Nov 18	17.99	53.3
21	Nov 15	17.96	17.9
25	Nov 15	18.00	17.9
29	Nov 15	18.03	17.9
Section 1	Nov 24	18.26	58.6
Section 2	Nov 24	18.28	58.6

(1) Locations shown on Figures 2 and 13
(2) Instantaneous Flow at Elmcroft Hydrometric Gauge

An approximate calibration of the HEC-2 model was made using the above data. The estimated flow for the 1 in 100 year open water event was then used in the model to produce estimates of the flow profile. The starting water level was assumed to be equal to the estimated water level at St. George plus 1.2 m to account for head loss in the reach between Bonny River and St. George. The estimate of head loss used the estimated average slope of the water surface which was measured during the 1979 flood.

The modelling with the HEC-2 program examined the sensitivity of the upstream water levels to the flow assumed in the River. The effect of a variation in the assumed downstream water level was also examined as part of the sensitivity study. Table 11 shows the flow profile for the 1 in 100 year flow, with a plus and minus 10% variation in the flow. It also presents the

effect of a 0.2 m variation in the elevation assumed for the water level at Section 1.

Table 11
Flow Profile (Bonny River Area)

Flow (m^3/s)	Water Level Section 1 (m)	Water Level Section 2 (m)
Q_{100}	**22.44**	**22.55**
Q_{100} - 10%	22.44	22.53
Q_{100} + 10%	22.44	22.57
Q_{100}	22.24	22.37
Q_{100}	22.64	22.73

The results from this modelling are estimates given that only two cross-sections have been used and the model has been calibrated on only one event. The event used in calibration was not an extremely high flow, and there has been no verification on a separate water level and flow. The assumptions made for the roughness of the floodplain are estimated, as the flow was confined to the bank during the period of the field program. These assumptions would affect the water surface profiles which would occur during high flow events, such as the 1 in 100 year open water flood.

A comparison to the slope of the water surface under high flow, as indicated by the observed levels in 1923 and 1979, shows a greater slope than calculated with the HEC-2 model. This difference is possibly due to much greater flow resistance in the

overbank area than has been used in the HEC-2 model. Also the very limited amount of cross-sectional data which may not provide a good estimate of the average channel slope. Therefore, the water level estimated using the 1979 flow profile has been used. This gives a level of 22.75 m at cross-section 2.

5.0 ENVELOPE OF MAXIMUM FLOODING

5.1 Water Level Profiles

During the research and interview phase of the study, information on a total of 13 flooding events was found covering the period 1887 to 1988. The initial screening of the data produced a list of 56 reference points, representing a total of 103 individual water levels in the Study Area. The field survey found elevations for 40 of the reference points, representing a total of 73 individual water levels. A reduction in number from the original screening is due, in part, to a re-evaluation of the points once the survey data became available. Table 12 summarizes the water levels established for each of the points, the reliability of each point is provided.

The water level points have been plotted on a profile of the River to permit comparison between the maximum water levels for each flood event. The maximum elevation for each flood can be determined and the overall envelope of maximum flooding can be estimated from these. Figure 16 shows a plot of the points found during this study. It can be seen that the levels for the 1923 event are consistently higher than any other event on the River.

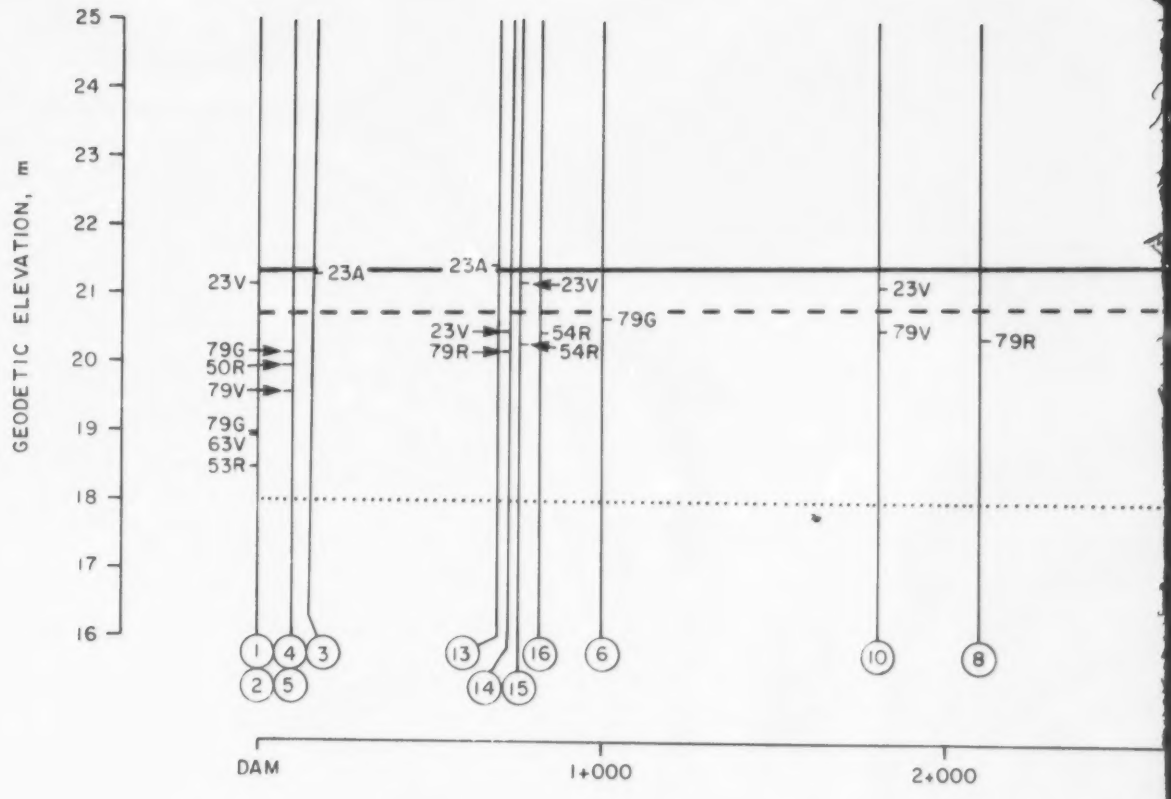
There are some points which exceed the maximum levels as established by the envelope of flooding. The elevations for these points are questionable because they exceed the general trend of the maximum water level established by the other water levels measured in the Study Area.

TABLE 12 ELEVATIONS OF WATER LEVEL POINTS

Pt #	1923	1936	1950	1953	1954	1959	1961	1963	1970	1973	1979	1984	Ice Scar
1				18.47 R	Y		Y	18.93 V			18.96 G		
2	21.16 V												
3	21.27 A												
4				Y	Y								
5			19.96 R								20.13 G		
6											19.56 Y		
8											20.65 G		
9			20.29 R								20.39 R		
10	23.65 V										20.54 G		
11			20.62 V								22.85 G		
13	21.60 A										20.42 G		
14	20.64 V												
15	21.18 V				20.28 R		Y				20.14 R		
16					20.42 R								
19	22.70 V												
20													
21	21.52 V				20.30 V	20.00 V	20.30 V		20.30 R		20.41 G		
23					21.33 A		21.33 A						
24											21.03 R		
25											21.03 G		
26											20.27 G		19.71 G
27	21.67 V												20.36 G
28											21.07 A		
29									Y				
30													19.58 G
31	21.65 V								21.22 A		21.47 G		
32	22.50 R		20.75 R			21.41 R	21.00 R				21.19 G		
33									21.66 R		20.98 G		
34	23.16 A										21.70 G		
36	23.15 A								22.26 A				
37													
38											22.07 G	22.45 V	
42									23.57 R				
44											24.02 A		
45	Y												20.15 G
46	24.63 V												20.20 G
47													
48		22.93 V											20.93 G
49				20.99 R			22.93 V		Y				
51	Y		Y	Y			20.67 V				20.53 G		
52							20.65 A	19.81 A	20.30 A	19.89 A	20.48 G		

Point #	Control	Chainage
1	Horz Vert	0
2	Horz Vert	0
3	Horz Vert	150
4	Horz Vert	100
5	Horz Vert	100
6	Horz Vert	1000
8	Vert	2100
9	Vert	3020
10	Vert	1800
11	Vert	3100
13	Horz Vert	700
14	Horz Vert	750
15	Horz Vert	760
16	Horz Vert	820
19	Horz Vert	3280
20	Vert	3620
21	Horz Vert	5000
23	Vert	5600
24	Vert	5960
25	Horz Vert	6260
26	Horz Vert	6670
27	Horz Vert	7000
28		9150
29	Horz Vert	10000
30	Vert	10820
31	Horz Vert	11720
32	Horz Vert	14100
33	Horz Vert	14300
34	Vert	14950
36	Horz Vert	15750
37	Vert	16600
38	Horz Vert	17160
42	Horz Vert	17500
44	Vert	13020
45	Horz Vert	12800
46	Horz Vert	9500
47	Vert	9400
48	Horz Vert	8820
49	Vert	7700
51	Vert	5300
52	Vert	5300

NOTE: ELEVATIONS IN METRES


GEODETIC ELEVATION, E
25
24
23
22
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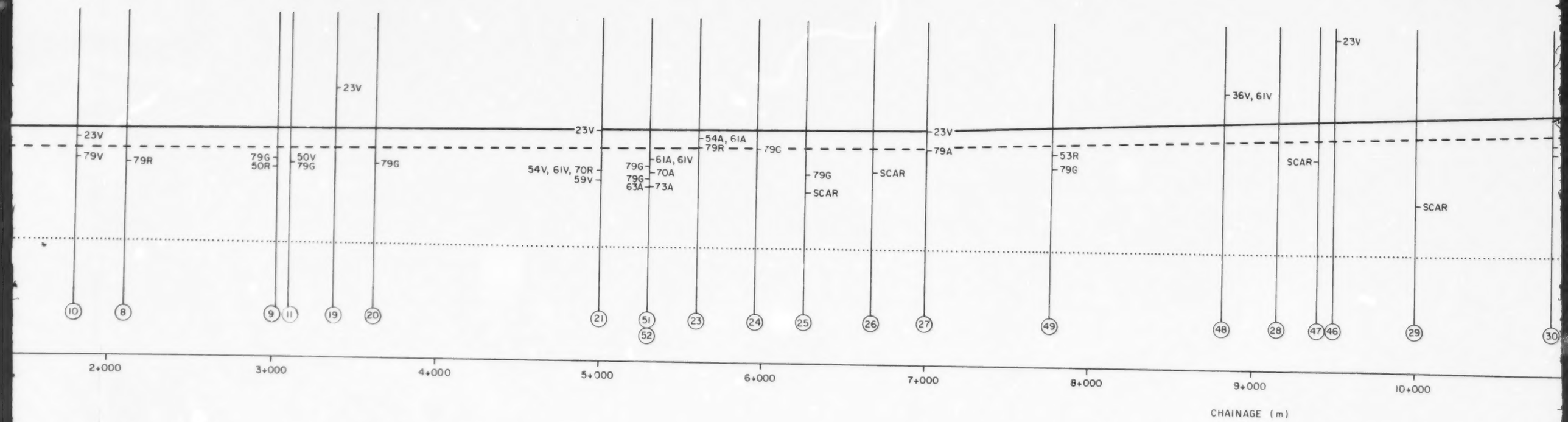
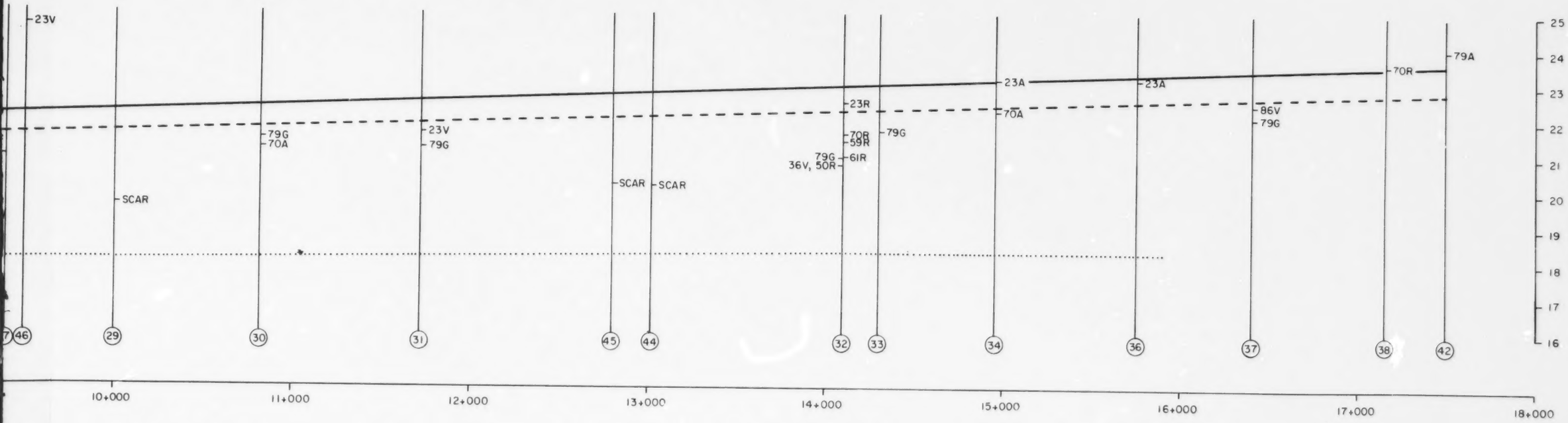
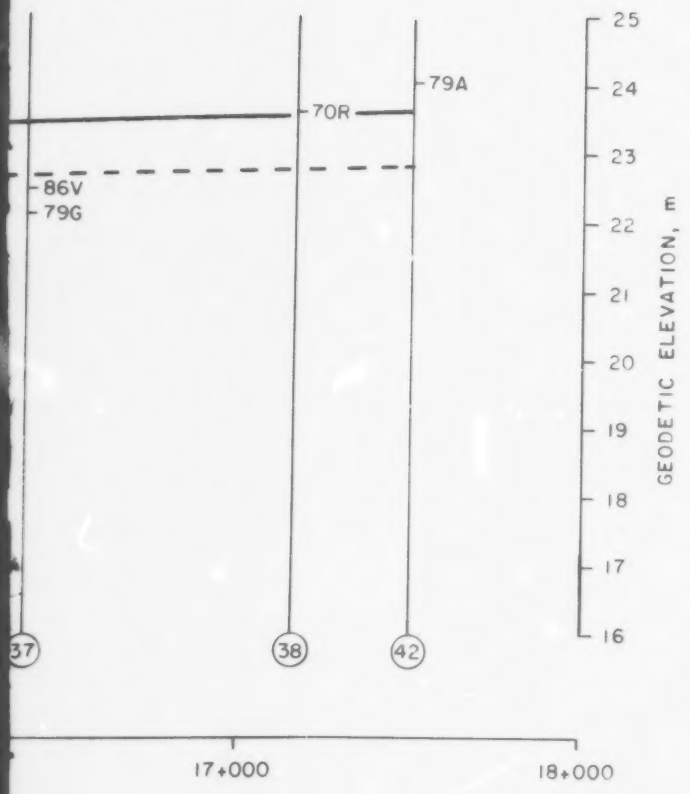
20
19
18
17
16
23V
23A
23A
23V
23V
79G
23V
54R
79V
79R
79R
54R
79G
50R
79V
79G
63V
53R
1
4
3
2
5
13
16
6
14
15
10
8
DAM
1+000
2+000


23V
23V
79V
79R
79G
50R
50V
79G
79G
23V
54V, 61V, 70R
59V
79G
63A
61A, 61V
70A
73A
54A, 61A
79R
79G
79G
SCAR
SCAR
23V
79A
53R
79G
36V, 61V
SCAR
23V
SCAR
10
8
9
11
19
20
21
51
52
23
24
25
26
27
49
48
28
47
46
29
30
2+000
3+000
4+000
5+000
6+000
7+000
8+000
9+000
10+000
CHAINAGE (m)

LEGEND

.....	NOVEMBER 1988 WATER LEVEL PROFILE
———	MAXIMUM HISTORIC FLOOD PROFILE
– – –	1 IN 100 YEAR OPEN WATER PROFILE
61V	YEAR 1961, AND RANKING OF POINT
G	GOOD
R	REASONABLE
A	APPROXIMATE
V	VAGUE
(33)	REFERENCE POINT





CANADA - NEW BRUNSWICK
FLOOD DAMAGE REDUCTION PROGRAM
AN ASSESSMENT OF FLOOD DAMAGE POTENTIAL
ALONG THE MAGAGUADAVIC RIVER VALLEY

MAGAGUADAVIC RIVER VALLEY WATER LEVEL PROFILES

wms associates ltd.
ENVIRONMENTAL CONSULTANTS AND SCIENTISTS

DATE: 89 01 06	SCALE: VERT. 1:100 HORIZ. 1:20 000
DRAWN BY:	APPROVED BY:
FIGURE No.: 16	

The analysis of the data and selection of points to be included in the envelope of maximum flooding showed that the 1923 event clearly represented the maximum historic flood event. There have been changes on the River since 1923; the dam was raised by 1.5 m in 1950 and the bridge above the dam was replaced in 1974, both of which influence the flood levels in the River. However, without detailed hydraulic analysis, it is difficult to determine the impact of the changes. It has been assumed that the influences would offset one another and the water levels would not be drastically different from the levels which could occur with a flow similar to the estimated magnitude of the 1923 event.

5.2 Flood Profiles

The profile of the River and the elevations of floods along it were used to determine the elevation of flooding from each known flood event and the maximum historic flooding envelope in the River valley.

There are not enough points, nor sufficient information to provide the exact extent of flooding along the River. Water levels are reported as heights against structures and not as the maximum extent of inundation. Therefore the locations selected to define the maximum limit of flooding are based on the maximum elevation of flood waters in each section of the River. The general slope of the water surface has been selected based on the observations from the 1979 flood. The water level profiles are shown in Figure 16.

The location of the flood lines could be determined using the contour information on the maps and spot elevations which were available in some areas. The contour interval on the mapping was 5 m on the 1:10,000 scale maps and 2 m on the 1:2400 scale maps. This interval is large enough so that one contour interval covers

a large area of the floodplain, making location of the flood lines difficult. Aerial photography of the River valley was therefore used to assist in determining the location of the flood lines. Preliminary maps showing the extent of flooding have been included with the supplementary data (WMS, 1989).

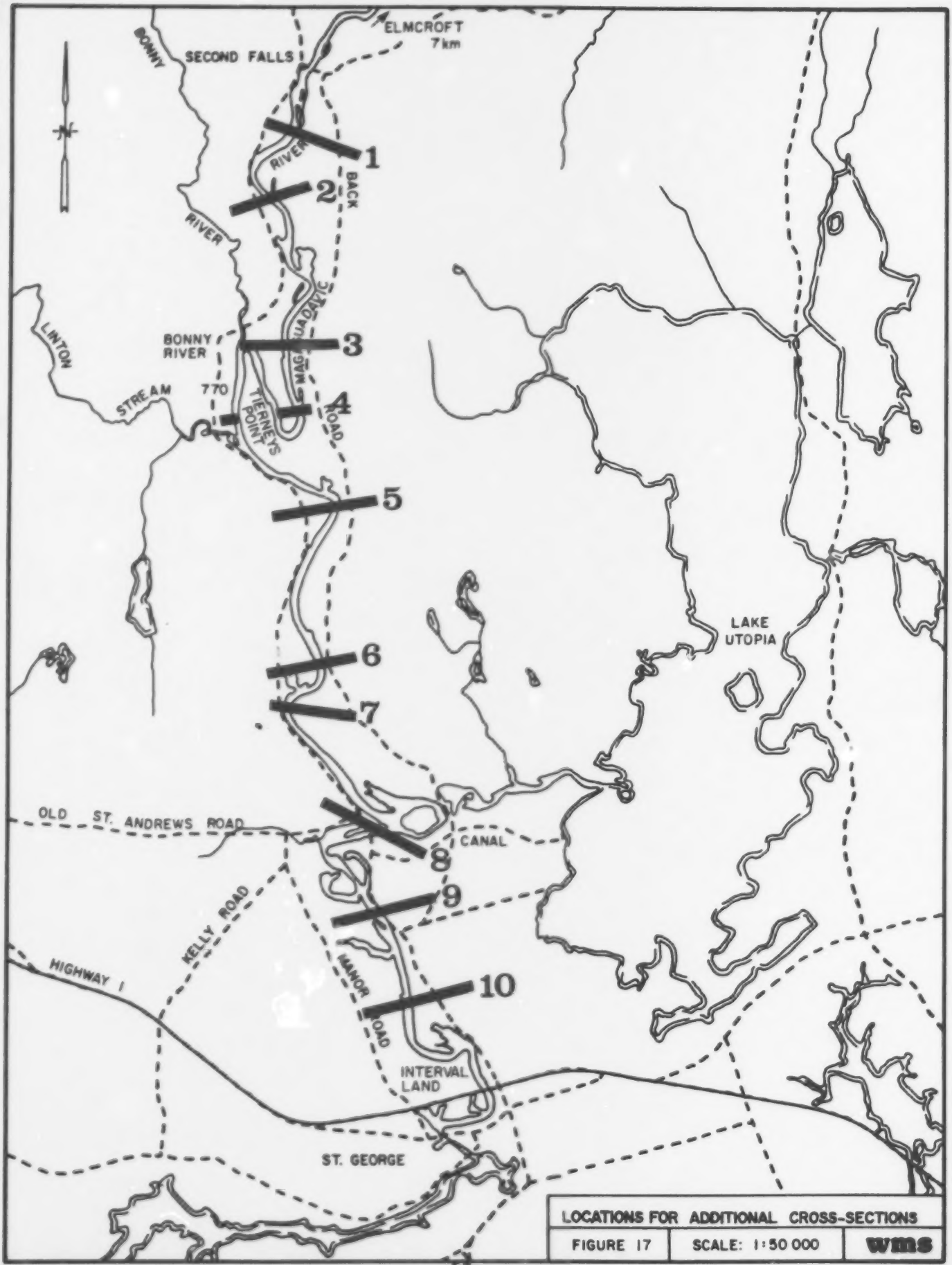
To improve upon these data, cross-sections of the River valley could be taken in key locations within the Study Area to help confirm the location of the flood lines chosen. Figure 17 shows the suggested location of 10 cross-sections which could be used. The sections be taken as soon as possible so that the existing temporary benchmarks can be used to locate the sections, thereby reducing the difficulty and cost of obtaining the cross-sections.

The ranking of the water levels can be used to obtain an estimate of the accuracy of the flood profiles shown. The flood limit chosen is that of the 1923 flood, although most of the points obtained for this flood have the rank of "approximate" or "vague". The range of the water levels associated with these rankings are estimated to be ± 150 mm and ± 300 mm, respectively. The nature of the River valley is such that the limit of the flood will usually be near the change in slope at the edge of the valley.

5.3 Open Water Flood Limit

The hydrotechnical studies in Chapter 4 of this report determined the magnitude of the 1 in 100 year open water flood, and an estimate was made of the corresponding flood limits.

It was found that the 1 in 100 year limit was less than the historic maximum flood limit, as determined from the 1923 flood. This is to be expected, because the 1923 event was estimated to


ELMCROFT
7km
BONNY
SECOND FALLS
RIVER
BACK
RIVER
1
2
BONNY
RIVER
3
LINTON
STREAM
770
TIERNEYS
POINT
4
ROAD
5
LAKE
UTOPIA
6
7
OLD ST. ANDREWS ROAD
CANAL
8
9
KELLY ROAD
HIGHWAY 1
MANOR
ROAD
10
INTERVAL
LAND
ST. GEORGE
LOCATIONS FOR ADDITIONAL CROSS-SECTIONS
FIGURE 17
SCALE: 1:50 000
WMS

have a magnitude greater than that of the 1 in 100 year flood. The magnitude of the flow in 1923 was not verified, but it is evident that it exceeded all flows which have occurred since then. The 1923 event was an open water flow event caused by high runoff due to heavy rain and snowmelt (Section 3.3).

The magnitude of the flow estimated for the 100 year event was similar to that recorded for the 1970 event at the Elmcroft hydrometric gauge; the estimated flood limit was shown to be lower in the upstream section of the River than the level recorded in 1970. During the 1970 event, there was an ice jam in the Tierney's Point area of the River, which would cause elevated water levels upstream of the jam. The water levels recorded downstream of the jam are reasonably close to those estimated for the 1 in 100 year open water event.

The influence on flood levels of the dam at St. George and operation of the spillway was not accurately defined. The discharge curves and storage volume curves which have been used were estimates, and the discharge through the plant and the height of stoplogs at each gate during specific flood events was not known. The estimate of the open water flood level was made assuming that there was no power being generated at the hydroelectric plant, and that all the stoplogs would be in place at the dam.

The open water flood limit at the dam has been extended up to Bonny River using the approximate slope of the water surface profile observed during the 1979 flood. The level was used as a starting level for estimates of the flow profile in the Second Falls to Bonny River area. Approximate modelling of the flow profile was used to obtain the estimate of the 1 in 100 year profile in this reach of the River.

6.0 DEVELOPMENT POTENTIAL

6.1 Data Collection

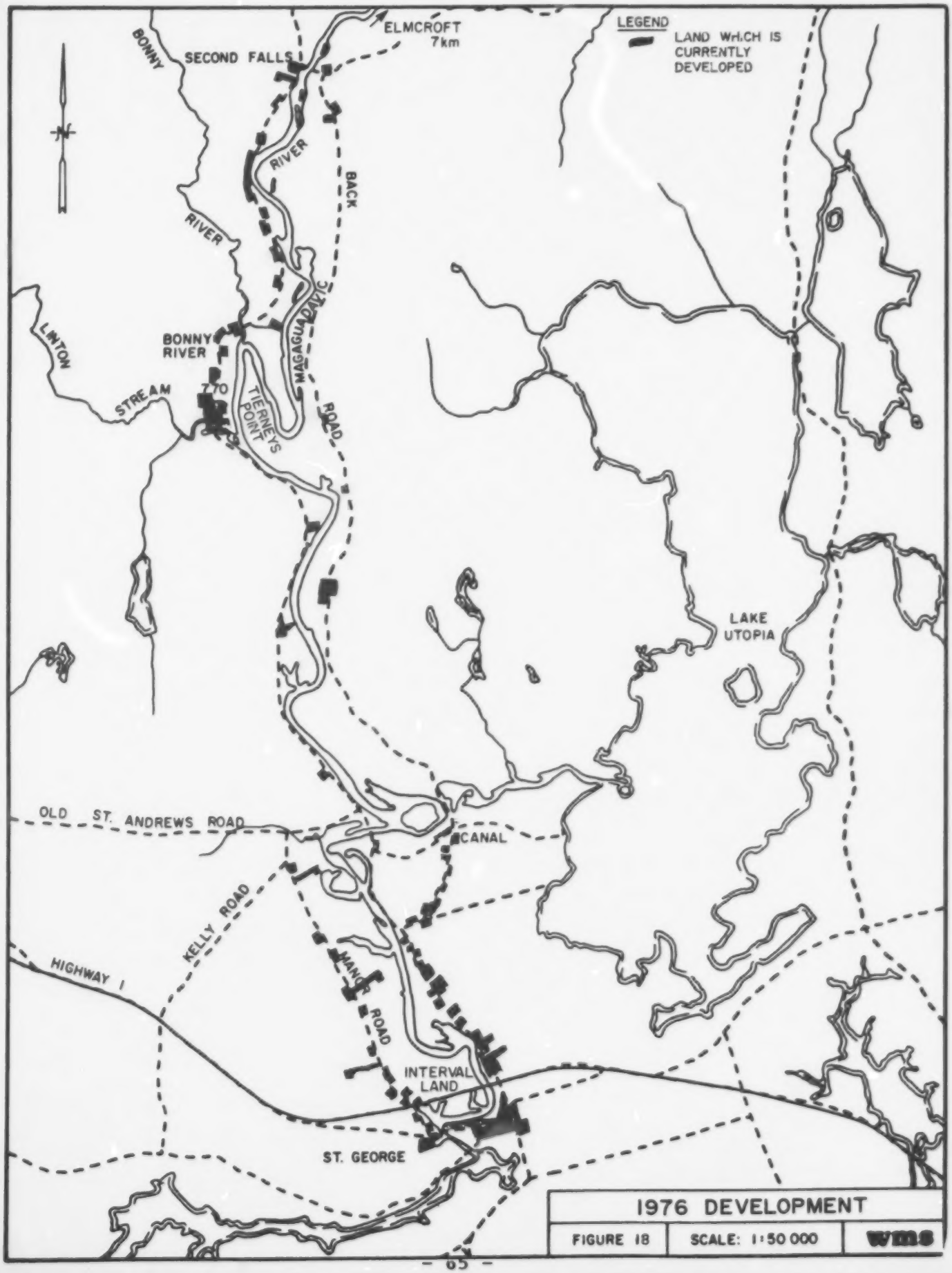
Land use and demographic information were used in determining the past development trends and future development potential along the Magaguadavic River. Current and past land use data provided information on how the land has been used to date and how these various uses related to each other. This data provided an indication of how future development will relate to the existing uses and which activities may be supported on the land. Demographic data provided information on past, present and future population trends in the Study Area. These data outlined the rate of growth in the area and provided a strong indication of the amount of residential land within the Study Area.

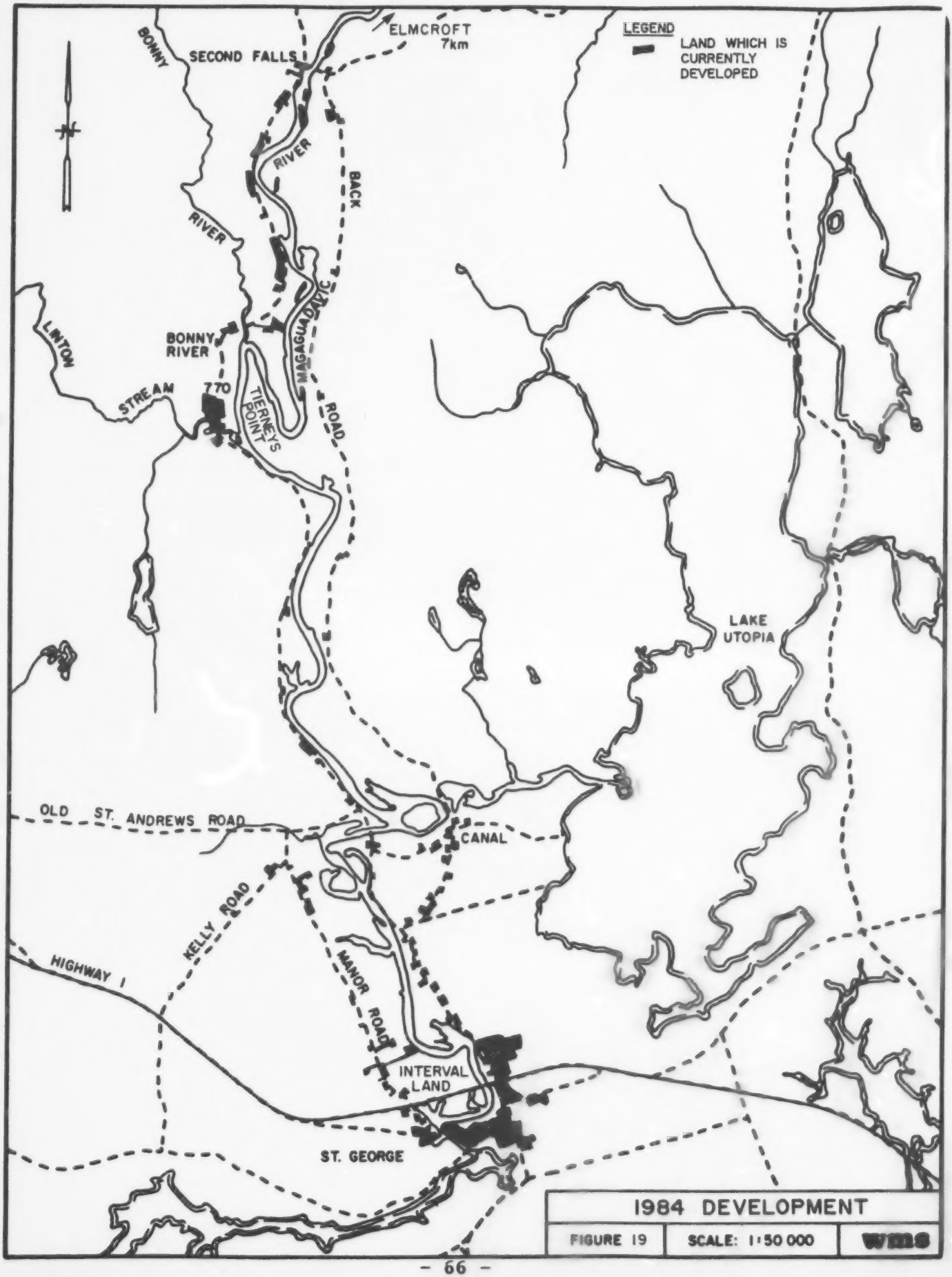
Land use data were collected from the following sources:

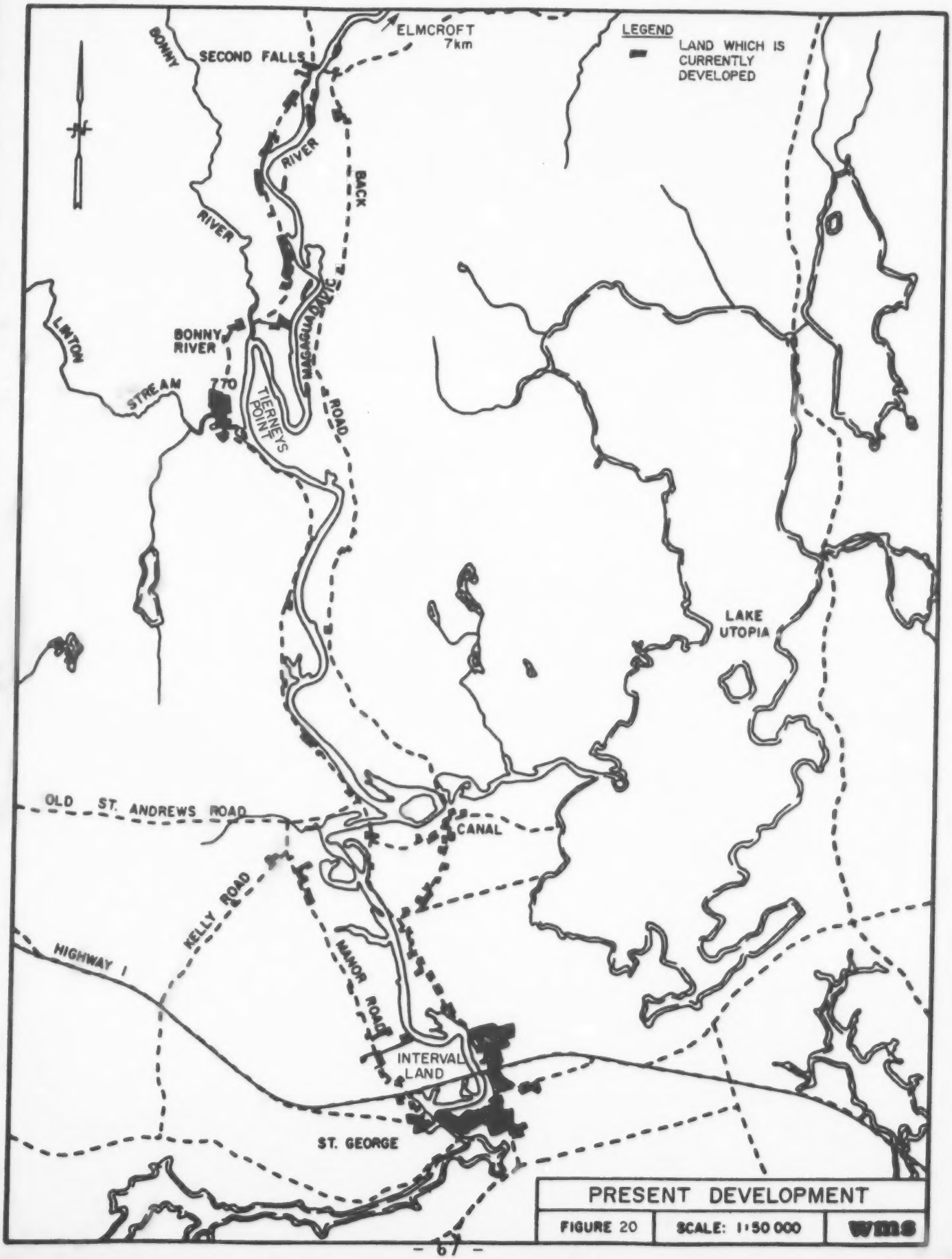
- LRIS property maps and listings;
- interpretation of aerial photography of the Study Area; and,
- field reconnaissance by automobile.

A land use map was initially plotted from aerial photography, and then confirmed in the field. Aerial photography was available for the area for 1976 and 1984. Figures 18, 19 and 20 show the development along the River for 1976, 1984 and 1988 respectively. The development shown on these figures is areas of cleared land on which there is a building which is currently being used.

The current land use and property ownership information have been compiled into a database using dBase III Plus which allows for


LEGEND
LAND WHICH IS CURRENTLY DEVELOPED
ELMCROFT 7km
SECOND FALLS
BONNY
RIVER
BACK
RIVER
MAGAGUADAVIC
LINTON
STREAM
BONNY RIVER
770
TIERNEYS POINT
ROAD
LAKE UTOPIA
OLD ST. ANDREWS ROAD
CANAL
KELLY ROAD
HIGHWAY 1
MANCE ROAD
INTERVAL LAND
ST. GEORGE
1976 DEVELOPMENT
FIGURE 18
SCALE: 1:50 000
WMS


ELMCROFT
7km
LEGEND
LAND WHICH IS CURRENTLY DEVELOPED
BONNY
SECOND FALLS
RIVER
BACK
RIVER
LINTON
BONNY RIVER
STREAM
770
TIERNEY'S POINT
MAGAHAMDAY
ROAD
LAKE UTOPIA
OLD ST. ANDREWS ROAD
CANAL
KELLY ROAD
HIGHWAY 1
MANOR ROAD
INTERVAL LAND
ST. GEORGE
1984 DEVELOPMENT
FIGURE 19
SCALE: 1:50 000
WRS


ELMCROFT
7km
LEGEND
LAND WHICH IS CURRENTLY DEVELOPED
BONNY
SECOND FALLS
RIVER
BACK
RIVER
MAGAUADAVIC
LAWTON
BONNY RIVER
STREAM
770
TIERNEYS POINT
ROAD
LAKE UTOPIA
OLD ST. ANDREWS ROAD
CANAL
KELLY ROAD
HIGHWAY 1
MANOR ROAD
INTERVAL LAND
ST. GEORGE
PRESENT DEVELOPMENT
FIGURE 20
SCALE: 1:50 000
WMS

easy organization, manipulation, retrieval, and updating of large amounts of data.

All properties within the Study Area have been recorded in the database. Much of the information was obtained using Land Registration and Information Service (LRIS) property maps and listings. Other information was obtained from land use maps, field reconnaissance, and zoning maps and by-laws. The database includes the following fields for each record (property):

- LRIS numbers;
- owner's last name;
- owner's first name;
- owner's address;
- municipality;
- property municipality;
- current land use; and
- area.

A hard copy of the database is included in Appendix C.

Demographic information was obtained primarily from the Census of Canada and the New Brunswick Statistics Agency. The most recent census was held in 1986. Information from previous census surveys was used to determine trends in population growth. Aerial photographs and LRIS property listings were also used to determine population trends within the Study Area. Since the

Study Area is determined by natural features rather than political or economic boundaries it was necessary to estimate the population within the Study Area by determining the number of dwellings from aerial photographs and LRIS listings then multiplying by the average number of persons per dwelling for the area from census information.

6.2 Demographic Analysis

The population has been projected for the Study Area from population growth forecasts for New Brunswick and by regression analyses on past trends within Charlotte County.

The first method uses population forecasts based on the Provincial growth rate, as estimated by the New Brunswick Statistics Agency. This method assumes that Charlotte County is growing at the same rate as the rest of the Province. The population within the Province is currently increasing slowly, at a rate of 0.3% per year.

The second method used to forecast population growth is based on a linear regression on the population of Charlotte County from the census counts in 1966, 1971, 1976, 1981, and 1986. The population trend was projected based on the average annual change in population for the years that actual population data was available.

A third method used to forecast the population growth also used linear regression based on past trends. The regression was performed using the annual change in population rather than the actual population.

All three methods show that there will be no appreciable change in the population over the next 20 years.

The population within the Study Area was estimated by counting the number of households within the Study Area and multiplying by an estimate of the average household size of 2.7 (the actual figure for the Town of St. George from the 1986 Census) (Statistics Canada, 1986). From existing mapping and aerial photographs it is estimated that there is a total of 58 households. Using this data it is estimated that current population is 157.

6.3 Development Potential

The development potential along the Magaguadavic River appears to be low. Residential development is very closely linked to industrial development and other employment generators. The supply of jobs in Charlotte County is increasing at a rate which is much slower than the natural increase in population creating a deficiency of jobs. It has been estimated that by 1991 there will be a deficiency of 1,781 jobs in Charlotte County (Department of Municipal Affairs, 1978). The St. George area of Charlotte County has a high level of retail and service type of employment; thus the level of growth in the region will be stable and should continue to increase at a rate similar to the past trends.

Based on the population projections in Section 6.2, no significant amount of residential development is expected to take place in the floodplain. St. George and the surrounding area acts as a bedroom community for Saint John to a small extent. Those who commute to Saint John from the St. George area are generally those who grew up in the area. It is expected that these people will continue to commute from St. George to Saint John. Because of the distance from Saint John and the abundance of developable land closer to Saint John, it is not expected that

development in Saint John will have a significant effect on residential development in the St. George area.

Agriculture is limited in the floodplain area. The land in the floodplain is classified as Class 4 to Class 5 in the Canada Land Inventory Soil Capability for Agriculture (Langmaid and Veer, 1967). These soils have severe limitations that restrict the range of crops or require special conservation practices. Little agricultural development is expected in the floodplain in the future.

There are no extensive forestry operations taking place in the floodplain, although pulp and paper companies own approximately 13 percent of the land in the Study Area. There is one small logging operation on Back Road approximately 4 km south of Second Falls.

The areas which show the greatest potential for increased activity are recreation and tourism. Recreational activities such as fishing and boating will only be marginally affected by flooding, and therefore these types of activities are acceptable and can thrive within the floodplain.

Within the next five to ten years the demographic analysis shows that there will be very little development within the floodplain area. Most of the development within the Town limits will probably be in the urban area of the Town. Any other development will continue to be along the transportation routes as is presently the case.

Development over the next 15 years and longer will be dependant upon new major employment generators in the region. The development of Lepreau 2 or a major industry locating in St. George could have a large impact on the population and

development patterns within St. George. Without new industry, it is possible that the population in St. George may even decrease as was the case in the last census period.

There is enough land in the urban portion of St. George to support the expected development for the next 15 to 20 years. After this, development will begin to spill into the rural areas of the Town. The Municipal Development Plan will have to be amended before this to prepare for the long term future development of the Town. It is expected that most future development will be inside the Town or very close to the Town limits.

7.0 CONCLUSIONS AND RECOMMENDATIONS

This study has found that the open water flood of 1923 is the highest on record, far exceeding the levels reached by any other flood, whether caused by open water or ice jamming. It has been found that a minor amount of flooding occurs every year in the Study Area and that major floods are relatively frequent. The information collected on flooding has been used to establish the maximum envelope of flooding for the Study Area.

High runoff from heavy rain and snowmelt is the major cause of flooding. Ice jamming does occur, but it appears that the jams usually release before the levels become extreme. Ice scars on trees in the Study Area indicate scarring at relatively low elevations.

A detailed hydrotechnical study of the area would permit the flood elevations to be more firmly established throughout the Study Area. Such a study would permit an assessment of the impact of changes which have been made to the River valley since the flood of record in 1923, such as those to the bridge and dam at St. George. A hydrotechnical study is not warranted, however, due to the small number of houses affected and the limited development potential of the area.

There are not enough points, nor sufficient cross-sectional information to provide the exact extent of flooding along the River. Water levels are reported generally as heights against structures and not as the maximum extent of inundation. Therefore the water levels selected to define the maximum limit of flooding are based on the maximum elevation of flood waters in each section of the River.

To permit a full determination of the extent of flooding, cross-sections could be taken to supplement the available mapping of the area. The use of existing temporary benchmarks which were established for this study would reduce the difficulty and cost of obtaining the cross-sections.

From existing mapping and aerial photographs it was estimated that there are a total of 58 households, and a current population of 157 in the area affected by flooding. It is projected that there will be very little population growth in the next 5, 10 or 15 years. Almost half of the employment in the Town of St. George and St. George Parish is in stable employment sectors, therefore, such as retail and service sectors, little variance from the projected population or development within the Study Area should be expected.

Demographic analysis shows that within the next five to ten years there will be very little development within the floodplain area. Most of the development within the Town limits will probably be in the urban area of the Town away from the floodplain. Any other development will continue to be along the transportation routes as is presently the case.

This study can provide a useful guide to any development which does take place within the Study Area. The elevations of maximum flooding determined by this study can be used to ensure that new development does not take place in areas which would be affected by flooding. The profile of maximum flooding should be used as a guide to determine the elevation of flooding in the area of interest.

8.0 REFERENCES

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APPENDIX A

Ice Breakup Times

ICE-OUT OF LAKE UTOPIA*
CHARLOTTE COUNTY, N.B.

YEAR	DATE	YEAR	DATE	YEAR	DATE
1895	April 22	1941	April 20	1983	April 20
1896	April 22	1942	April 23	1984	April 26
1897	April 28	1943	April 30	1985	April 19
1898	April 20	1944	April 20	1986	April 15
1899	April 28	1945	April 5	1987	April 18
1900	April 20	1946	April 18	1988	April 11
1901	April 20	1947	April 14		
1902	March 25	1948	April 22		
1903	April 20	1949	April 13		
1904	April 18	1950	April 21		
1905	May 6	1951	April 2		
1906	April 15	1952	April 17		
1907	April 28	1953	March 27		
1908	April 23	1954	April 17		
1909	April 17	1955	April 27		
1910	April 20	1956	April 16		
1911	April 21	1957	April 20		
1912	April 18	1958	April 14		
1913	May 3	1959	April 28		
1914	April 10	1960	April 26		
1915	April 17	1961	May 3		
1916	April 24	1962	April 18		
1917	April 22	1963	May 2		
1918	April 20	1964	April 30		
1919	April 14	1965	April 17		
1920	April 16	1966	May 2		
1921	April 18	1967	April 17		
1922	April 28	1968	April 29		
1923	April 10	1969	April 25		
1924	April 21	1970	May 4		
1925	April 20	1971	May 9		
1926	May 7	1972	April 18		
1927	April 20	1973	April 12		
1928	April 18	1974	April 29		
1929	April 20	1975	April 29		
1930	April 16	1976	April 16		
1931	April 24	1977	April 26		
1932	April 20	1978	April 28		
1933	April 18	1979	April 13		
1934	April 26	1980	April 13		
1935	April 20	1981	April 5		
1936	April 14	1982	April 27		
1937	April 20				
1938	April 20				
1939	May 7				
1940	April 20				

* Collected by Clayton Tatton

DATES OF "ICE-OUT" ON LAKE UTOPIA*

Date	Ice-out	Date	Ice-out	Date	Ice-out
1985	April 22	1951	April 3	1970	April 24
1896	April 22	1952	April 16	1971	May 1
1897	April 28	1953	March 27	1972	May 9
1898	April 20	1954	April 18	1973	April 18
1899	April 28	1955	April 15	1974	April 1
1902	March 25	1956	April 28	1975	April 29
1923	May 1	1957	April 16	1976	April 2
1926	May 7	1958	April 13	1977	April 25
1937	May 7	1959	April 28	1978	April 28
1938	April 20	1960	April 26	1979	April 6
1939	May 7	1961	May 4	1980	April 12
1942	April 23	1962	April 14	1981	April 6
1943	April 30	1963	May 1	1982	April 26
1945	April 5	1964	April 27	1983	April 5
1946	April 18	1965	April 29	1984	April 19
1947	April 14	1966	April 17	1985	April 18
1948	April 22	1967	May 1	1986	April 13
1949	April 13	1968	April 17	1987	April 18
1950	April 21	1969	April 29	1988	

* Collected by K. Chase

Note:

1895-1945	Obtained From Austen Goodeill by K. Chase
1923-May 1, 2, 3	Highest freshet ever, in this area.
1902-March 25	Earliest break-up.
1972-May 9	Latest break-up.

Appendix B

List of Persons Interviewed
Sample Interview Forms - Officials
- Residents
- Individual Flood Events

PERSONS INTERVIEWED

No.	Name	Date
1	Ross Norman	Sept. 26, 1988
2	Bob Allen	Sept. 26, 1988
3	Kensell Chase + (Cora)	Sept. 26,29, 1988
4	Steve Campbell + (Bernice)	Sept. 26,29, 1988
5	Eileen Lee	Sept. 28, 1988
6	H. Allison Craig	Sept. 28, 1988
7	Al Corbett	Sept. 28, 1988
8	Doug Haney	Sept. 28, 1988
9	Eleanor Dougherty	Sept. 28, 1988
10	Laura Haley	Sept. 28, 1988
11	Albert Stevens & Amber Stevens-Sentse	Sept. 29, 1988
12	Gerry Bourque	Sept. 29, 1988
13	Steve Linton	Sept. 29, 1988
14	Alden Goodrich	Sept. 29, 1988
15	Clayton Tatton	Sept. 29, 1988
16	Alden & Eugenia Stevens	Sept. 30, 1988
17	Elizabeth Stevens	Sept. 29, 1988
18	Neil Buchanon	Sept. 30, 1988
19	Merlin & Marjori Frost	Sept. 30, 1988
20	Nellie Lee	Sept. 30, 1988
21	Earl Watson	Oct. 3, 1988
22	Postmistress	Sept. 30, 1988 Oct. 3, 1988
23	Marion Bain	Oct. 3, 1988
24	Heather Brown-Bartlett	Oct. 4, 1988
25	Rose Haughn - St. Andrews	Oct. 4, 1988
26	Charles Mason - St. Andrews	Oct. 4, 1988
27	Rick McMullin - St. Andrews	Oct 4, 1988
28	Dr. Carl Medcof - St. Andrews	Oct. 4, 1988
29	Anita Grearson	Oct. 4, 1988
30	J.D. Tait	Oct. 4, 1988
31	Henry Hatt, Plant foreman	Oct. 5, 1988
32	Arthur Parks	Oct. 5, 1988
33	Everett Dewar	Oct. 5, 1988
34	Norman Vance	Oct. 5, 1988
35	Lawrence Stewart	Oct. 5, 1988
36	Mildred Parks	Oct. 5, 1988
37	Elizabth Toy	Oct. 5, 1988
38	Charlie & Edith Davis	Oct. 5, 1988
39	Elmore Winters	Oct. 6, 1988
40	Louise and Darb Gilmore	Oct. 6, 1988
41	Minnie Brown & Marguerite Craig	Oct. 6, 1988
42	Lyla Chambers	Oct. 6, 1988
43	Melvin Matheson	Oct. 6, 1988
44	Steven Eldridge	Oct. 7, 1988
45	Stuart Lee	Oct. 7, 1988

Persons Interviewed (Continued)

No.	Name	Date
46	Marion MacVicar & Myrtle Henderson	Oct. 7, 1988
47	J. Crammond	Oct. 7, 1988
48	R. & E. Maxwell	Oct. 7, 1988
49	James Allen	Oct. 12, 1988
50	Lewis Dillman	Oct. 12, 1988

ASSESSMENT OF FLOOD DAMAGE POTENTIAL
MAGAGUADAVIC RIVER

LOCAL OFFICIALS INTERVIEW GUIDE

Name: _____

Organization: _____

Position: _____

Address: _____

_____

Telephone: _____

Interview guide # | | |

1. What years do you remember the Magaguadavic River flooding?

_____ _____ _____

Fill in Flood Information form for each year.

2. Does your organization have any records that provide information on past floods, such as the height of water, location of ice jams, photographs and films of flooded areas, locations of high water marks, damages (direct & indirect)?

No ——— Go to Q.3

Yes ——— Fill in Flood Information form for each event and/or piece of information

3. Do you personally have any records or other type of information that provide information on past floods, such as the height of water, location of ice jams, photographs and films of flooded areas, locations of high water marks, damages (direct & indirect)?

No ——— Go to Q.4

Yes ——— Fill in Flood Information form for each event and/or piece of information

4. Can you think of any other individuals or organizations that may have that type of information or evidence?

No Yes ——————— Could you please provide names, locations and telephone numbers so that we may contact these individuals?

(a) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(b) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(c) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(d) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(e) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

ASSESSMENT OF FLOOD DAMAGE POTENTIAL
MAGAGUADAVIC RIVER

LOCAL RESIDENTS INTERVIEW GUIDE

Name: _____

Address: _____

_____

Telephone: _____

Location: _____

Interview guide # [ ][ ]

1. What years do you remember the Magaguadavic River flooding?

_____ _____ _____

Fill in Flood Information form for each year.

2. Do you personally have any records, recollection or other type of information that provide information on past floods, such as the height of water, location of ice jams, photographs and films of flooded areas, locations of high water marks, damages (direct & indirect)?

No ——— Go to Q.3

Yes ——— Fill in Flood Information form for each event and/or piece of information

3. Can you think of any other individuals or organizations that may have that type of information or evidence?

No Yes _____ Could you please provide names, locations and telephone numbers so that we may contact these individuals?

(a) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(b) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(c) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(d) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(e) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

ASSESSMENT OF FLOOD DAMAGE POTENTIAL
MAGAGUADAVIC RIVER

FLOOD EVENT INFORMATION FORM

Interview guide # [ ][ ]

A. Date event started: _____

Time: _____ DK ( )

B. Date event peaked: _____

Time: _____ DK ( )

C. Duration of flood: _____

D. Type of Flood: Ice Run ( ) Open Water ( )
Ice Jam ( ) Not Known ( )

(i) Do you know where the ice jam was located?
No ( ) ——— Go to E.
Yes ( ) Please describe the location and height of jam (if known). (Provide sketch or location on map)

_____

_____

(ii) Do you have photographs, films or videos that show the ice jam?

No ( ) ——— Go to E.
Yes ( ) ——— Photograph ( ) Video ( )
Film ( ) Other ( )

Can we have access to a copy of these?
Print provided ( )
Negatives provided ( )
Lent for duration of study ( )
Can ask for it when doing actual surveying ( )
Photo of photo ( )

E. Describe location and extent of flood waters. (Provide sketch or location on map.)

_____

_____

_____

F. How high was the flood? (Describe or give level if known):

_____ _____

_____

_____

G. What damages did the flood cause to specific structures and what was the cost of damages.

None ( )
Don't know ( )

Structure	Damages	Cost
_____	_____	$_____
_____	_____	$_____
_____	_____	$_____
_____	_____	$_____
_____	_____	$_____
_____	_____	$_____
_____	_____	$_____

H. Are you aware of any remaining scars, physical marks or evidence of flooding (e.g. on buildings, trees, other structures) that show the level the water reached?

No ——— Go to I.
Yes

(i) Please describe the location and the type of mark as accurately as possible so that our surveyors may locate it. (Take photograph an provide sketch and/or location on map)

Description and Location of Marks

_____

_____

_____

_____

_____

I. Do you have any photographs, films or videos that show this flood event (or the marks you mentioned)?

No
Yes ——— Photograph ( ) Video ( )
Film ( ) Other ( )

Can we have access to a copy of these?

Print provided	( )
Negatives provided	( )
Lent for duration of study	( )
Can ask for it when doing actual surveying	( )
Photo taken of mark	( )
Photo taken of photo	( )

Appendix C

Land Use Database

WMS ASSOCIATES LTD.

MAGAGUADAVIC RIVER FLOOD DAMAGE
POTENTIAL STUDY

LRIS NUMBER	OWNER'S LAST NAME	OWNER'S FIRST NAME	OWNER'S ADDRESS			PROPERTY LOCATION	LAND USE	AREA (SQ. METRES)
124029							RES	2400
125939							OPEN	1025
1214402	St. Croix	Pulpwood Co.	Woodland, Maine U.S.A.	Woodland	04694	Canal Road, Magaquadavic River, N.B.	OPEN	240
1214519	St. Croix	Pulpwood Co.	Woodland, Maine U.S.A.	Woodland	04694	Canal Road, Magaquadavic River, N.B.	OPEN	13000
1214691	St. Croix	Pulpwood Co.	Woodland, Maine U.S.A.	Woodland	04694	Canal Road, Magaquadavic River, N.B.	OPEN	6400
1214956	St. Croix Pulp-	Wood Ltd.	Woodland Maine, U.S.A.	Woodland	0469	Canal Road, Magaquadavic River, N.B.	OPEN	28000
1214980	Hunnewell	Roger	St. George, N.B.	St.George	E0G2Y0	Riverview Avenue, Magaquadavic River, N.B.	OPEN	970
1219575	Needle	Francis	St. George, N.B.	St.George	E0G2Y0	Manor Road, St. George	OPEN	1840
1219583	Corning	Donald	St. George, N.B.	St.George	E0G2Y0	Manor Road, St. George	OPEN	1840
1220110	Toy	Eugene	St. George, N.B.	St.George	E0G2Y0	Riverview Avenue, St. George, N.B.	OPEN	3800
1220128	Toy	Eugene	St. George, N.B.	St.George	E0G2Y0	Riverview Avenue, St.George, N.B.	OPEN	1900
1231398							RES	563
1231554	Andrews	John	St. George, N.B.	St.George	E0G2Y0	Riverview Avenue, St. George, N.B.	RES	855
1234095	Whitford	Michael	Box 144, St. George, N.B.	St.George	E0G2Y0	Riverview Avenue, St. George	OPEN	7400
1237528							RES	6000
1237551							OPEN	7000
1237676	Canadian Pacifi	Railway	Marathon Realty,Suite 1930 Montreal	Montreal		McQuirks Mountain, Bonney River, Montreal	OPEN	45000
1237676							OPEN	21150
1238369	Craig	Donald	St. George, Char. Co. N.B.	St.George	E0G2Y0	Second Falls Road, Bonny River Sta., N.B.	OPEN	10500
1238377							OPEN	13300
1238401	Craig (Estate)	Daisy T Estate	Box 29, Site 2 SS #3, Fredericton	Fredericto	E3B5W9	Dawson Mt., Magaquadavic River, N.B.	RES	16200
1238542							OPEN	5100
1238542							RES	400
1238567	Parks	Tilley	St. George, N.B.	St.George	E0G2Y0	Manor Road Canal, N.B.	OPEN	1850
1238567							OPEN	255100
1238567							RES	1850
1238658	Dillman	Levis	RR #3, St. George, N.B.	St.George	E0G2Y0	Dellman Road Canal, N.B.	OPEN	3500
1238815	Hawkins	Kenneth	Pennfield, Char. Co.	Pennfield	E0G2R0	Tierne Pt., Bonny River, N.B.	OPEN	1125500
1238849	Frost	Louis	RR #3, St. George Char. Co., N.B.	St.George	E0G2Y0	Canal Road, Second Falls, N.B.	OPEN	42500
1238906	Curling Club	St. George	St. George, N.B.	St.George	E0G2Y0	Manor Road, St. George, N.B.	REC	3903
1238963	Williamson	K. G.	C/O G.P. Williamson RR #3Rothesay	Rothesay		Cov Lake Stream, Bonny River, N.B.	OPEN	150
1238971							OPEN	223300

WMS ASSOCIATES LTD.

MAGAGUADAVIC RIVER FLOOD DAMAGE
POTENTIAL STUDY

LRIS NUMBER	OWNER'S LAST NAME	OWNER'S FIRST NAME	OWNER'S ADDRESS	PROPERTY LOCATION	LAND USE	AREA (SQ. METRES)
1239144						
1239151	Hall	Lester	RR #3, St.George, Char. Co.	St.George E0G2Y0 Linton Stream, Bonny River, N.B.	RES	8100
					OPEN	160
1239250	Harvey	Joan	Apt 1709, 25 Silver Spring, Scar/ON	Scarborouq M1V1N9 Canal Magaguadavic River, N.B.	OPEN	7000
1239342	Hatt	Stanley	St. George Char Co., N.B.	St.George Maxwells Road Canal, N.B.	OPEN	3000
1239375	Hatt	Windsor	RR #3, St. George Char Co., N.B.	St.George E0G2Y0 Canal Road Canal, N.B.	OPEN	380
1239565					OPEN	400
1239987	Steen	Buddy, L.	RR #3, St. George, NB	St. George E0G2Y0 Second Falls Magaguadavic River	OPEN	400
1240266	Stewart	Lee	RR #3, St. George, NB	St. George E0G2Y0 Canal Road, Second Falls	OPEN	180
1240704	Langmaid	Wilfred	RR #3, St. George, N.B.	St.George E0G2Y0 Dillman Road, (parcel X), Canal, N.B.	OPEN	160
1241173						
1241322	McVicar	Milton, I	RR# 3, Char. Co., St. George, NB	St. George E0G2Y0 Bonny River Road, Bonny River Station	RES	8000
					OPEN	2000
1241744	St. George	Pulp & Paper Co	P.O. Box 5777 Saint John, N.B.	Saint John E2L4M3 Vernon Island Canal, N.B.	OPEN	59500
1241793	St. George	Pulp & Paper	P.O. Box 5777, Saint John, N.B.	Saint John E2L4M3 770 Hwy. Canal, N.B.	OPEN	12600
1241801	St.George Pulp	and Paper Ltd.	P.O. Box 5777, Saint John	Saint John E2L4M3 Grey Mountain Lake, Utopia, N.B.	OPEN	2100
1241868	St.George Pulp	and Paper Ltd.	P.O. Box 5777, Saint John,	Saint John E2L4M3 Mcquirks Mt, Cow Lake, N.B.	OPEN	46800
1241884					OPEN	8400
1241959					OPEN	606460
1242122	Stevens	James	RR #3, St. George, Char. Co.	St.George E0G2Y0 Canal Road, Magaguadavic River, N.B.	OPEN	17600
1242437	Trynor	George	St. George, N.B.	St.George E0G2Y0 770 Hwy. Canal, N.B.	OPEN	8100
1242676	Thomas	Fidele	34 Westmorland Road, Saint John	Saint John E2J2E2 Old St. Andrews Road Canal, N.B.	OPEN	109050
1242676						
1243815	Gill	Douglas	1191 Newton Road,Oakville, Ontario	Oakville Bonny River Road, Bonny River	RES	250
					OPEN	2000
1244409	Hooper	Graham	Box 275, St. George, N.B.	St.George E0G2Y0 770 Hwy. Canal, N.B.	OPEN	420
1245067					OPEN	11000
1245455	Martin	Leroy	115 Myles Ave., Gondola Pt,Rothesay	Rothesay E0G2W0 Canal Magaguadavic River, N.B.	OPEN	8100
1245497	Highrock Inc.		150 Purchase St.,Fall River,Mass.	Mass.USA 02720 Canal Road Canal, N.B.	OPEN	1032400
1245497						
1253939					OPEN	63000
1289032	Seamans	William	1258 North Curtis Av. Covina Ca./US	California Riverview Ave., St. George, N.B.	RES	370
					OPEN	1150
1313196	Dick	Ronald	RR #4 St. George, N.B.	St.George E0G2Y0 Manor Road, St. George, N.B.	COM	929
1313220	Balasiuk	Mary	St. George, N.B.	St.George E0G2Y0 Riverview Ave., St. George, N.B.	OPEN	1150

WMS ASSOCIATES LTD.

MAGAGUADAVIC RIVER FLOOD DAMAGE
POTENTIAL STUDY

LRIS NUMBER	OWNER'S LAST NAME	OWNER'S FIRST NAME	OWNER'S ADDRESS			PROPERTY LOCATION	LAND USE	AREA (SQ. METRES)
1313253								
1313337	Whitford	Michael	St. George, N.B.	St.George	E0G2Y0	Riverview Ave., St. George, N.B.	OPEN	890
							RES	2602
1313444								
1313535	Boy Scouts		Manor Road, St. George	St.George		Manor Road, St. George, N.B.	OPEN	192
1313568							OPEN	360
1313592	McCluskey	William	St. George, N.B.	St.George	E0G2Y0	Manor Road, St. George	RES	1202
1313592							OPEN	520
1313782	Clinch	Alice	Riverview Avenue, St. George	St.George		River View Avenue, St. George, N.B.	RES	200
							RES	245
1313840	St. George	Funeral Service	St. George, N.B.	St.George	E0G2Y0	Wallace Street, St. George	OPEN	168
1313899	Boyd	Alice	Main Street, St. George	St.George		Main Street, St. George, N.B.	COM	126
1313956							RES	130
1313964	Thompson	Brent	49 Riverview Avenue, St. George	St.George	E0G2Y0	Riverview Avenue, St. George	RES	145
1313980	Dewar	Everett	Manor Road, St. George	St.George		Manor Road, St. George	OPEN	68600
1314012							RES	330
1314087	Holmes	Allen	St. George, N.B.	St. George	E0G2Y0	North Street, St. George	RES	60
1314202	Fraser	Florence	St. George, N.B.	St.George		Manor Road, St. George	OPEN	54000
1314202							RES	3300
1314244							RES	474
1314509	Hawker	Phillip	River view Avenue, St. George N.B.	St.George		River view Avenue, St. George, N.B	RES	80
1314517							OPEN	3000
1314624	Henry	Grace	St. Stephen Rd, St. George	St.George		Old Hwy, St. George, N.B.	RES	100
1314632	Norman	John	St. Stephen Rd., St. George	St.George		Old Hwy., St. George, N.B.	RES	120
1314855							RES	30
1314863							RES	100
1315092	Kierstead	Mobile Homes	D 1055 Manawagonish Rd. St.John,N.	St. John		Manor Road, St. George, N.B.	RES	400
1315126	Boone	Richard	St. George, N.B.	St.George	E0G2Y0	North Street, St. George, N.B.	RES	2454
1315183							RES	50
1315266	Vance	Norman	St. George, N.B.	St.George	E0G2Y0	Main Street, St. George, N.B.	COM	90
1315332	Hooper	Enterprises Ltd	Pennfield, N.B.	Pennfield	E0G2R0	Main Street, St. George, N.B.	COM	130
1315373	Cross	Evelyn	St. George, N.B.	St.George	E0G2Y0	Brunswick St., St. George, N.B.	RES	600
1315407								
1315456							RES	500
1315464	Kernighan	Robert	St. George Char. Co., N.B.	St.George		Campbell Street, St. George, N.B.	RES	1115
							IND	6740
1315613	McGrattan	Charles	Brunswick St., St. George	St.George		Brunswick Street, St. George, N.B.	RES	1375
1315787	Town of St.Geor	Linda Jean	St. George, N.B.	St.George	E0G2Y0	Brunswick St., St. George, N.B.	INST	600
1315829	Mahar	Shirley	St. George, N.B.	St.George	E0G2Y0	Brunswick St., St. George, N.B.	RES	900

WHS ASSOCIATES LTD.

MAGAGUADAVIC RIVER FLOOD DAMAGE
POTENTIAL STUDY

LRIS NUMBER	OWNER'S LAST NAME	OWNER'S FIRST NAME	OWNER'S ADDRESS			PROPERTY LOCATION	LAND USE	AREA (SQ. METRES)
1315852	Norman	John	St. Stephen Road, St. George, N.B.	St. Stephe		Old Hwy St. George, N.B.	OPEN	30
1316009							OPEN	2800
1316108	Rubin	Nathan	St. George Char. Co., N.B.	St.George		Main Street, St. George, N.B.	OPEN	12000
1316140							OPEN	3100
1316249	Lees Auto	Supplies Ltd.	St. George, N.B.	St.George	E0G2Y0	Old Hwy., St. George, N.B.	COM	882
1316322	Spear	Amy	Box 202, St. George, N.B.	St.George	E0G2Y0	Old Hwy., St. George	RES	40
1316363	Irving Ltd.	J.D.	P.O. Box 5777, Saint John, N.B.	St. John	E2L4W3	Manor Road, St. George, N.B.	OPEN	10000
1316413							OPEN	446
1316546	Henry	Daniel	St. George, N.B.	St.George	E0G2Y0	Main Street, St. George	COM	50
1316587	St. George	Curling Rink	c/o W C Hawker, St. George	St.George		Manor Road, St. George, N.B.	REC	3485
1316686	Taylor	Doris	Manor Rd., St George	St.George	E0G2Y0	Manor Rd., St. George, N.B.	OPEN	12800
1316686							RES	840
1316736	Toy	Eugene	St. George, N.B.	St.George	E0G2Y0	Riverview Avenue, St. George, N.B.	RES	4800
1316884							RES	420
1316900	Vance	Norman	Minor Road, St. George	St.George		Manor Road, St. George, N.B.	RES	1812
1316959	Kee	Frederick	51 Brunswick St., St. George,N.B.	St.George	E0G2Y0	Brunswick St., St. George	OPEN	371
1317056	St.George Pulp	& Paper Ltd.	P.O. Box 5777, Saint John, N.B.	Saint John	E2L4W3	Brunswick Street, St. George, N.B.	OPEN	60
1317064	St.George Pulp	& Paper Ltd.	P.O. Box 5777, Saint John, N.B.	Saint John	E2L4W3	Campbell Street, St. George	IND	88
1317551	Barry	James	St. George, N.B.	St.George	E0G2Y0	Manor Road, St. George, N.B.	OPEN	2720
1317627	Guitard	Mary	Beaver Harbour, N.B.	Beaver Har	E0G1C0	Manor Road, St. George, N.B.	OPEN	47800
1317627							RES	450
1317668	Henry	Gary	1090 St. Germain Cres. Orleans,Ont.	Orleans	K1C2L8	Manor Road, St. George, N.B.	OPEN	100
1317734							OPEN	22
1326701	Henry	Daniel	St. George, N.B.	St.George	E0G2Y0	Main Street, St. George, N.B.	COM	90
1326735	St. George Pulp	and Paper Ltd.	P.O. Box 5777, Saint John, N.B.	Saint John	E2L4W3	Riverview Avenue, St. George, N.B.	OPEN	100
1327840	Town of	St. George	St. George, N.B.	St.George		Manor Road, St. George	OPEN	488
1328756	Maxwell	Ruth	St. George, N.B.	St.George	E0G2Y0	Off Main Street, St. George, N.B.	OPEN	65
1328764	Cousins	Edward	St. George, N.B.	St.George	E0G2Y0	Off Main Street, St. George, N.B.	OPEN	225
1329390	St.George Pulp	& Paper Ltd.	P.O. Box 5777, Saint John, N.B.	Saint John	E2L4W3	Hwy. #1, St Stephen Road, St. George, N.B.	OPEN	384600
1334283							OPEN	37
1340546	Shaw	Jack, H.	c/o RR# 3, St. George, NB	St. George	E0G2Y0	Second Falls Magaqaudavic River	OPEN	800
1340603	Municipal	Affairs & Env	P.O. Box 6000, Fredericton, NB	F'ton	E3B5H1	Magaquadavic River, Second Falls	OPEN	20000

WMS ASSOCIATES LTD.

MAGAGUADAVIC RIVER FLOOD DAMAGE
POTENTIAL STUDY

LRIS NUMBER	OWNER'S LAST NAME	OWNER'S FIRST NAME	OWNER'S ADDRESS			PROPERTY LOCATION	LAND USE	AREA (SQ. METRES)
1340686	St. Croix	Pulpwood Co.	Woodland, Maine, USA	Maine	04694	Canal road, Magaguadavic River	OPEN	5400
1340694	St. Croix	Pulpwood Co.	Woodland, Maine, USA	Maine	04694	Canal Road, Magaguadavic River	OPEN	22500
1340967	Crammond	John	204 Pitt Street, Saint John, N.B.	Saint John	E2L2X1	Canal Road, Magaguadavic River, N.B.	OPEN	2000
1340991	Mcvicar	Archibald Estat	Marion Mcvicar, RR #3, St.George	St.George	E0G2Y0	Canal Road, Bonny River Station, N.B.	OPEN	809700
1341007	Stevens	James	St. George, N.B.	St.George	E0G2Y0	Canal Road, Magaguadavic River, N.B.	OPEN	35000
1341023	St. Croix	Pulpwood Co.	Woodland Maine, U.S.A.	Woodland	04694	Canal Road, Magaguadavic River, N.B.	OPEN	18500
1341163	Goss (Estate)	Hollis Estate	c/o Sadie Goss, RR #3, St.George	St.George	E0G2Y0	Bonny River Road, Bonny River Station, N.B.	OPEN	180
1341205	Hall	James	RR #3, St. George, N.B.	St.George	E0G2Y0	Bonny River Road, Bonny River Station, N.B.	OPEN	180
1341262							RES	800
1341361							RES	4000
1341395							OPEN	1200
1341403							RES	120
1341452							RES	20200
1341460	St. Croix	Pulpwood Ltd.	Woodland, Maine, USA	Maine	0469	Canal Road, Second Falls	OPEN	72000
1341478	Campbell	Pauline	Bonnie River Char. Co. N.B.	Bonnie R.		Canal Road, Bonny River, N.B.	OPEN	16400
1344563	St. George Pulp & Paper Co. Ltd		P.O. Box 5777, Saint John, N.B.	Saint John	E2L4N3	Public Landing, St. George, N.B.	OPEN	3903
1344571	Hawkins	Kenneth	Pennfield, N.B.	Pennfield	E0G2R0	770 Hwy. Canal, N.B.	OPEN	1150
1501663							OPEN	360
15001753	Archibald	Campbell, A.	RR# 3, St. George, NB	St. George		River Road, Second Falls	OPEN	6100
15009986	Mackenzie	Anna	814 Campbell St., Winnipeg, Man.	Winnipeg	R3N1C6	Riverview Ave. W/S, St. George, N.B.	OPEN	301
15010150							OPEN	28
15010572							RES	4000
15010580	Clark	Ellison	St. George Char Co., N.B.	St.George	E0G2Y0	770 Hwy. Canal, N.B.	OPEN	7400
15010598							OPEN	970
15010598							RES	370
15010606	Watt	Brian	St. George Char Co., N.B.	St.George	E0G2Y0	770 Hwy. Canal, N.B.	RES	7400
15010630	Seamans	Harry	River Road, St. George, N.B.	St.George	E0G2Y0	770 Hwy. Canal, N.B.	OPEN	2100
15010648							OPEN	700
15010655							OPEN	1500
15010671	Stewart	Horace	P.O. Box 129, St. George, N.B.	St.George	E0G2Y0	770 Hwy. Canal, N.B.	OPEN	10950
15010697	Allen	James	RR #4 St. George, N.B.	St.George	E0G2Y0	Canal Road Canal, N.B.	OPEN	2100
15010705	Genge	David	190 University Ave., St.Johns,Nfld.	St.John's		Manor Road, St. George, N.B.	OPEN	246900
15010713							RES	32400
15010721							RES	4000
15010739							OPEN	3300
15010739							OPEN	1393

WMS ASSOCIATES LTD.

MAGAGUADAVIC RIVER FLOOD DAMAGE
POTENTIAL STUDY

LRIS NUMBER	OWNER'S LAST NAME	OWNER'S FIRST NAME	OWNER'S ADDRESS	PROPERTY LOCATION			LAND USE	AREA (SQ. METRES)
15010747								
15010754							RES	230
15010838	Bradford	Victor	St. George, N.B.	St.George	E0G2Y0	770 Hwy. Canal, N.B.	RES	1012
15010952	St. George	Pulp & Paper	P.O. Box 5777, Saint John, N.B.	Saint John	E2L4M3	Magaguadavic River Canal, N.B.	OPEN	23545
15010960	St. George	Pulp & Paper	P.O. Box 5777,Saint John, N.B.	Saint John	E2L4M3	Magaguadavic River Canal, N.B.	OPEN	32400
15010978	St. George Pulp and Paper Ltd.		P.O.Box 5777, Saint John, N.B.	Saint John	E2L4M3	Old St. Andrews Road, Canal, N.B.	OPEN	56700
15011349							OPEN	58700
15011349							OPEN	10930
15011356	Bridges	Brothers	P.O. Box 96, St. Stephen, N.B.	St.Stephen	E0G3A0	Old St. Andrews Road Canal, N.B.	RES	1170
15011364	St. Croix	Pulpwood Co.	Woodland Maine, U.S.A.	Woodland	04694	Old St. Andrews Road Canal	OPEN	14200
15011380							OPEN	2050
15017098							OPEN	4000
15022080	Norman	Rossia	RR# 3, St. George, NB	St. George	E0G2Y0	HWY 770 Bonney River Sta	OPEN	232
15022767	Young	Jeanne	St. George, N.B.	St.George	E0G1G0	Riverview Ave., St. George, N.B.	RES	36400
15023559	N.B.	Transportation	P.O. Box 6000, Fredericton, N.B.	Frederic.	E3B5N1	Parcel 83-1,Hwy. 770, plan of hwy 770,magadav.riv.	OPEN	24300
15023567							OPEN	110
15023575							RES	9197
15023583	Winters	Elmore	RR #3, St. George, N.B.	St.George	E0G2Y0	770 Highway Canal, N.B.	RES	4513
15025935							RES	12100
15026578	Seamans	Norman	RR #3 St.George, N.B.	St.George	E0G2Y0	Riverview Ave, St. George, N.B.	COM	450
15026586	Seamans	Mary	St. George, N.B.	St.George	E0G2Y0	Riverview Ave., St. George, N.B.	OPEN	6100
15028509	Hanley	Marguerite	St. George, N.B.	St.George	E0G2Y0	Manor Rd., St. George, N.B.	OPEN	6600
15028780	Vance	Norman	St. George, N.B.	St.George	E0G2Y0	Main Road, St. George, N.B.	OPEN	2300
15029036	Langmaid	Wilfred	RR #3, St. George, N.B.	St.George	E0G2Y0	Dellman Road Canal, N.B.	OPEN	400
15033285							OPEN	160
15033582	St. George Pulp & Paper Ltd.		P.O. Box 5777, Saint John, NB	Saint John	E2L4M3	Booney River Road, Second Falls	RES	3600
15038219	Clark	James	129 Riverview Ave., St. George	St.George	E0G2Y0	Riverview Ave., St. George, N.B.	OPEN	6500
15040553	St. Croix	Pulpwood Co.	Woodland Maine, U.S.A.	Woodland	04694	Little Otter Brk., Magaguadavic River, N.B.	OPEN	1145
15045370							OPEN	20000
15045727							OPEN	911
15046287	Niemeyer	Carl	St. George, N.B.	St.George	E0G2Y0	46 Brunswick St., St. George, N.B.	OPEN	4047
15046683	Thorne	Robert	24 Main St, St. George, N.B.	St.George	E0G2Y0	Canal Rd. (Lot 86-1) Canal (Matt Subd), N.B.	RES	60
15051147	Delaney	Kevin	51 Francis St., Saint John, N.B.	Saint John	E2M4S2	Dillman Rd., (Lot 87-1) Canal, N.B.	OPEN	460
							OPEN	230

WMS ASSOCIATES LTD.

MAGAGUADAVIC RIVER FLOOD DAMAGE
POTENTIAL STUDY

LRIS OWNER'S NUMBER	OWNER'S LAST NAME	OWNER'S FIRST NAME	OWNER'S ADDRESS			PROPERTY LOCATION	LAND USE	AREA (SQ. METRES)
15053945	Maxwell	Ann	RR #3, St.George, N.B.	St.George	E0G2Y0	Dillman Rd. (Lot 88-2) Canal, N.B.	OPEN	40
15144926	Matheson	Brent	St. George, N.B.	St.George	E0G2Y0	Dillman Road, Lot 83-1, St.George, WR Langmaid sub	OPEN	260
*** Total ***								6227701